THIS NUMBER COMPLETES VOLUME 15

Volume 15 NOVEMBER-DECEMBER, 1950 Number 6

Food Research

Under the Editorial Guidance of

Z. I. KERTESZ SAMUEL C. PRESCOTT L. B. JENSEN

Heureux déjà d' avoir pu servir mes concitoyens et l' humanite, je me repose sur la justice, la générosité et les lumières d' un gouvernement sage qui ne cesse d' encourager et de protéger toutes les découvertes utiles.

—NICOLAS APPERT.

Published Six Times a Year by THE GARRARD PRESS, Champaign, Illinois

Made in the United States of America

Food Research

FOOD RESEARCH is an independent journal founded for advancement and dissemination of scientific knowledge regarding the field of foods. It is devoted to publication of results of original investigations and occasional reviews, in the fields of food and beverage technology, chemistry, and microbiology. The services of all members of the Editorial Board are given with this desire and with no financial return.

Neither the publishers nor editors assume responsibility for opinions expressed by authors of papers published in FOOD RESEARCH.

Manuscripts should be sent to the Editor-in-Chief, Z. I. Kertesz, New York State Agricultural Experiment Station, Geneva, New York.

FOOD RESEARCH is issued bimonthly. Six issues constitute a volume.

Subscription price: Domestic, $5.50 per year; to foreign countries, $6.00 per year. Single copies of current number, one dollar; to England, 4s. All subscriptions should be sent to the publishers or their agent.

Claims for copies lost in the mails must be received within thirty days (ninety days, foreign) of the date of issue. Notice of change of address must be received two weeks before date of issue.

New subscriptions and renewals are entered to begin with first issue of current volume.

All correspondence concerning advertising, reprints, orders for copies should be addressed to The Garrard Press, Champaign, Illinois.

European Agents

H. K. LEWIS & CO., LTD.
136 Gower Street
LONDON, W. C. 1, ENGLAND

THE GARRARD PRESS

Division of Twin City Printing Co.

Manufacturers and Publishers of Scientific Books and Periodicals

CHAMPAIGN, ILLINOIS, U. S. A.

Food Research

Volume 15 NOVEMBER-DECEMBER, 1950 Number 6

EDITORS

Z. I. KERTESZ
New York State Agricultural Experiment Station
Geneva, New York

SAMUEL C. PRESCOTT
Massachusetts Institute of Technology
Cambridge, Massachusetts

L. B. JENSEN
Swift & Co., Research Laboratory
Chicago 9, Illinois

EDITORIAL ASSOCIATES

F. C. BLANCK
Mellon Institute of Industrial Research
Pittsburgh 13, Pennsylvania

E. J. CAMERON
National Canners Association
Washington, D. C.

EVELYN G. HALLIDAY
Department of Home Economics
The University of Chicago
Chicago, Illinois

M. A. JOSLYN
University of California
Berkeley, California

MAX LEVINE
Chief, Bureau of Laboratories
Department of Health T. H.
P. O. Box 3378
Honolulu 1, T. H.

A. G. LOCHHEAD
Dominion Experimental Farms
Ottawa, Canada

R. W. PILCHER
American Can Company
Maywood, Illinois

DONALD K. TRESSLER
North Compo Road
Westport, Connecticut

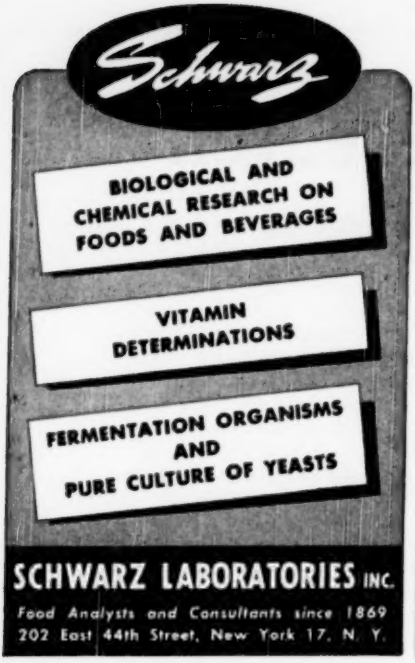
A. L. WHITING
Urbana Laboratories
Urbana, Illinois

CARL R. FELLERS
Department of Food Technology
University of Massachusetts
Amherst, Massachusetts

ROBERT J. GARRARD, *Managing Editor*
The Garrard Press
Champaign, Illinois

PUBLISHED SIX TIMES A YEAR

THE GARRARD PRESS
CHAMPAIGN, ILLINOIS


Schwarz
BIOLOGICAL AND CHEMICAL RESEARCH ON FOODS AND BEVERAGES
VITAMIN DETERMINATIONS
FERMENTATION ORGANISMS AND PURE CULTURE OF YEASTS
SCHWARZ LABORATORIES INC.
Food Analysts and Consultants since 1869
202 East 44th Street, New York 17, N. Y.

Wanted...

BACK VOLUMES
OF
FOOD RESEARCH

There is a need, particularly for libraries, of back volumes of FOOD RESEARCH. We shall be glad to purchase complete volumes and copies of certain single numbers.

THE GARRARD PRESS
Champaign, Illinois

12-YEAR
INDEX TO
FOOD RESEARCH

A Complete Index of
Volumes 1 Through 12

A complete collective index, both author and subject with all titles cross-indexed under key words.

Price, $2.00

Order now from

THE GARRARD PRESS
Champaign, Illinois

FOOD RESEARCH
LABORATORIES
INC.

INVESTIGATIONS
IN BIOCHEMISTRY AND
NUTRITION

BIOLOGICAL AND
MICROBIOLOGICAL ASSAYS

TOXICOLOGICAL STUDIES

Philip B. Hawk, Ph.D., *President*
Bernard L. Oser, Ph.D., *Director*

48-14 Thirty-third St. Long Island City, N.Y.

Laboratory Manual
and
WORK BOOK
in
Microbiology of Foods

Written and Compiled by
FRED W. TANNER

The Manual contains many official methods of food analysis and assembles a tremendous amount of useful data in one convenient workbook for ready reference in the laboratory. The standard 8½ x 11 size and loose leaf feature makes it convenient for the worker to add his own notes and build a valuable book summarizing data in which he is personally interested.

The Manual is printed by the photo-offset process. Much of the material is reproduced from the original printed page as it was first published in the literature. The bulk of the book has been composed on a varitype machine in clear, readable type adapted for laboratory use. The Manual contains many illustrations which help explain the methods described.

The sheets are punched to fit a standard three-ring binder. The Manual may be had with or without a binder.

Major Sections of the Manual

General
Bacteria
Yeasts
Molds
Sanitation
Milk
Milk Pasteurization
Butter
Cheese
Ice Cream
Miscellaneous Dairy Products
Eggs
Sugar and Starch
Flour and Bread
Meats
Sea Foods
Canned Foods
Tomato Products
Frozen Foods
Dried Foods
Nut Meats
Fruit Juices
Spices, Flavorings and Condiments

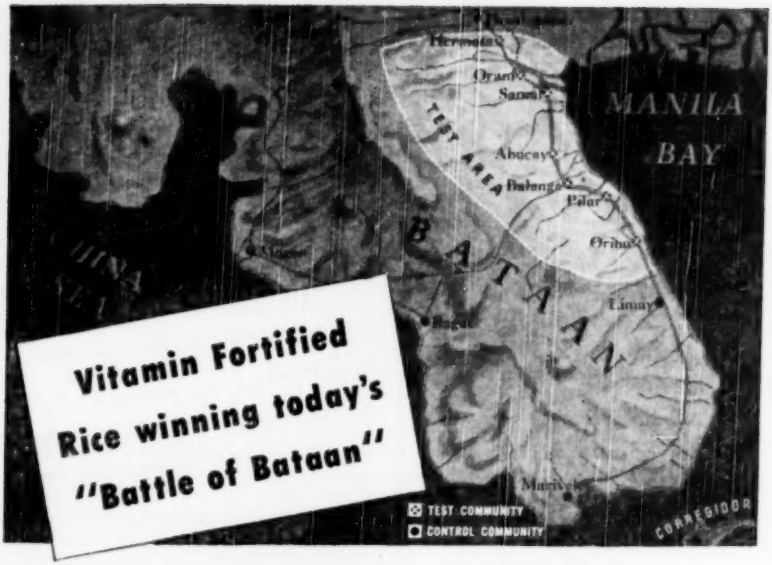
386 Pages 8½ x 11 Loose Leaf

PRICE WITHOUT BINDER, $4.75

PRICE WITH BINDER, $6.25

THE GARRARD PRESS, PUBLISHERS

CHAMPAIGN, ILLINOIS



RESULTS OF TREMENDOUS NUTRITIONAL EXPERIMENT USING VITAMIN ENRICHMENT

★ **Symptoms of 2nd most fatal disease reduced 70%**

★ **Beriberi deaths steadily falling**

★ **Infantile beriberi virtually eliminated**

In an experiment in the Philippines now involving over 90,000 persons, conducted with the approval of the Philippine government and medical associations, and in which Hoffmann-La Roche is proudly cooperating, remarkable health benefits from rice enrichment have been demonstrated. This is reported by Juan Salcedo, Jr., M.D., M.A., Director of Nutrition, Institute of Nutrition, Manila, P. I.

With rice the principal food, and beriberi the No. 2 cause of death, this new "Battle of Bataan" was planned and waged to determine whether enrichment of rice would reduce the incidence of beriberi. Bataan Province was selected because of its high beriberi mortality and because rice traffic could be readily controlled there. (Early investigation showed enriched rice completely satisfactory in taste, color, odor, palatability and digestibility.)

"There are indications from raw data available from the present clinical beriberi resurvey that the beriberi incidence has been reduced by 70%." Beriberi mortality rates have also steadily dropped in the "enriched rice" area without significant change in the control area.*

This dramatic and specific evidence of the benefits of vitamin enrichment should have a vital effect in improving the health of peoples all over the world.

WHAT THIS MEANS TO YOU

While these facts concern white rice, the conclusion is clear that vitamin and mineral enrichment of white bread, family white flour, macaroni, noodles, and other processed cereals is a direct and practicable way of correcting dietary inadequacies. The Bataan work confirms the judgment of nutritional experts who have advocated such enrichment, and further justifies legislation already enacted in 26 States, Puerto Rico and Hawaii requiring enrichment of all family white flour and white bread.

*Quotation from latest of published interim medical reports. *Write for reprint.*

ROCHE

VITAMINS FOR ENRICHMENT

VITAMIN DIVISION • HOFFMANN-LA ROCHE INC. • NUTLEY 10, N. J.

CONTENTS

HAZEL E. MUNSELL, LOUIS O. WILLIAMS, LOUISE P. GUILD, LUCILLE T. KELLEY, AND ROBERT S. HARRIS. Composition of Food Plants of Central America. VII. Honduras . . 421

HAZEL E. MUNSELL, LOUIS O. WILLIAMS, LOUISE P. GUILD, LUCILLE T. KELLEY, ANN M. MCNALLY, AND ROBERT S. HARRIS. Composition of Food Plants of Central America. VIII. Guatemala 439

ROY E. MORSE, JOHN J. POWERS, AND CARL J. WILLIAMS. Spores of *Clostridium botulinum* in Georgia Soil 454

ERNEST E. LOCKHART AND JEAN MURRAY GAINER. Effect of Monosodium Glutamate on Taste of Pure Sucrose and Sodium Chloride 459

CONRADO F. ASENJO, ORO DE BORINQUEN SEGUNDO, ANA I. MUNIZ, AND AIDA M. CANALS. Niacin Content of Tropical Foods . 465

KARLA LONGRÉE AND FAITH FENTON. Objective and Subjective Studies on Factors Affecting Toughness and Stringiness of Kale *(Brassica oleracea acephala)* 471

BERNARD E. PROCTOR, SAMUEL A. GOLDBLITH, AND HARVEY FRAM. Effect of Supervoltage Cathode Rays on Bacterial Flora of Spices and Other Dry Food Materials 490

M. G. VAVICH AND A. R. KEMMERER. The Carotenes of Cantaloupes 494

EDWARD A. MURPHY AND MAX S. DUNN. Nutritional Value of Peanut Protein 498

Published bimonthly by The Garrard Press, division of Twin City Printing Co., Champaign, Illinois. Domestic subscription, $5.50 per year; to foreign countries $6.00. Entered as second-class matter at the Post Office at Champaign, Illinois, under the act of March 3, 1879.

MADE IN THE UNITED STATES OF AMERICA

Announcement

At the meeting of the Council of the Institute of Food Technologists held in Chicago on May 24, 1950, an agreement was reached between the Institute and The Garrard Press that the ownership of FOOD RESEARCH be transferred to the Institute. This transfer has been now completed and FOOD RESEARCH thereby becomes an official publication of the Institute of Food Technologists.

During the same meeting the Council accepted the resignation of Dr. Fred W. Tanner, for the past fourteen years Editor-in-Chief of FOOD RESEARCH, and appointed Z. I. Kertesz of the New York State Agricultural Experiment Station, Cornell University, Geneva, New York, to become editor of FOOD RESEARCH as well as of FOOD TECHNOLOGY. The Council agreed to publish in FOOD RESEARCH all papers which were accepted for publication by the previous editors, and these papers constitute all but the last three papers printed in Volume 15, 1950, of this journal. The previous Co-Editors and Editorial Associates have all consented to continue to serve on the Editorial Board of FOOD RESEARCH.

Manuscripts for publication in FOOD RESEARCH should be now submitted to the new editor at the above address.

THE INSTITUTE OF FOOD TECHNOLOGISTS
THE GARRARD PRESS

COMPOSITION OF FOOD PLANTS OF CENTRAL AMERICA. VII. HONDURAS

HAZEL E. MUNSELL, LOUIS O. WILLIAMS, LOUISE P. GUILD, LUCILLE T. KELLEY, AND ROBERT S. HARRIS

Nutritional Biochemistry Laboratories, Massachusetts Institute of Technology, Cambridge, Massachusetts

[Received for publication, May 20, 1950]

This is the seventh in a series of reports which present results from analyses of samples of edible plants collected in the countries of Central America during the period from July, 1946 through July, 1949. The first six papers gave data on the following: I, 121 samples from Honduras, Munsell, Williams, Guild, Troescher, Nightingale, and Harris (1949); II, 124 samples of vegetables from Guatemala, Munsell, Williams, Guild, Troescher, Nightingale, and Harris (1950a); III, 106 samples, including 60 of fruits, from Guatemala, Munsell, Williams, Guild, Troescher, Nightingale, and Harris (1950b); IV, 194 samples from El Salvador, Munsell, Williams, Guild, Troescher, Nightingale, Kelley, and Harris (1950c); V, 51 samples from Nicaragua and four from Panama, Munsell, Williams, Guild, Troescher, and Harris (1950d); and VI, 154 samples from Costa Rica, Munsell, Williams, Guild, Kelley, McNally, and Harris (1950e). Data for an additional 91 samples collected in Honduras are given in this report.

The procedure for the collection and shipment of samples was the same as that described in the first paper; except for minor changes, the methods of analysis used for measuring the 13 constituents — moisture, nitrogen, ether extract, crude fiber, ash, calcium, phosphorus, iron, carotene, thiamine, riboflavin, niacin, and ascorbic acid — were the same as those noted in the second paper. Three slurries were made of all perishable products; staple foods were shipped, without treatment, in tightly-covered metal containers. A permanent record of each sample was made by color photography and by preservation of a botanical specimen in the herbarium at the Escuela Agrícola Panamericana in Honduras.

Information on altitude, prevailing soil type, and estimated annual rainfall in areas where samples originated is shown (Table 1).

The 91 samples were collected at various times from November, 1946 to August, 1948. Of the 24 taken at the Escuela Agrícola Panamericana (Zamorano), 20 were obtained in February, 1948, three in March, 1947, and one in November, 1946. The 16 samples from the Lancetilla Experimental Gardens, the 29 from farms of the Tela Railroad Company, and 21 of the 22 from markets were collected in July and August of 1948. The remaining sample, coffee, was purchased in February, 1948. From this summary it will be noted that only 22 of the samples were purchased in markets. All others were taken directly from plants. Fifty-one foodstuffs were represented, and there was more than one sample for eight of these.

DESCRIPTIONS AND USES OF FOODS STUDIED [1]

EARTH VEGETABLES:

Malanga colorada (I, *Malanga;* V, *Tisquisque;* VI, *Tequisque*). The sample comprised eight normal-sized, mature roots of the malanga, purchased in the market at La Lima. The skins were russet, underlaid with purple; the flesh was firm and white with some purple or rose color. For subsampling the roots were washed, peeled, and diced.

Rábano blanco (I and V, *Rábano*). Twenty mature radishes were purchased in the market in San Pedro Sula. These had white skins and firm white flesh and were slightly "hot." After the tops were removed, the roots were washed and trimmed and then diced without peeling, the subsamples thus containing flesh and skins.

TABLE 1

Areas Where Samples Originated, With Information on Prevailing Soil Type and Estimated Annual Rainfall

Town	Department	Altitude	Soil type	Estimated annual rainfall	No. of samples
		ft.		*in.*	
Arenales	Cortés	100	Sandy loam	20	2
Comayagua	Comayagua	2,000	.....	50	1
La Cumbre de San Pedro Sula	Cortés	1,000-2,000	.....	80-100	2
Curarén	Morazán	2,000	.....	50	1
Danlí	El Paraíso	2,000	.....	50	2
Guaruma—Farm No. 1	Cortés	100	Loam	17-20	10
Guaruma—Farm No. 2	Cortés	.....	Loam	20	4
Güinope	El Paraíso	4,200	Sandy loam	50	1
Lancetilla	Atlantida	200	Sandy loam	128	16
Lima Farm	Cortés	100	Loam	17	15
Río Abajo	Morazán	2,000	.....	50	2
San Juan Lindo	Cortés	2,000	.....	70	3
San Pedro Sula	Cortés	100	Sandy loam, loam, sand	60-80	5
Santa Barbara	Santa Barbara	600	.....	.....	1
Siguatepeque	Comayagua	4,500	Clay loam	50	1
Tela	Atlantida	0	Sand	80	1
Zamorano	Morazán	2,400	Clay loam	50	24

Remolacha (II and V, *Remolacha*). Eight large, mature, well-grown beets made up the sample. These were taken from the ground at the Escuela Agrícola Panamericana. For subsampling they were peeled and cubed.

Zanahoria (I and V, *Zanahoria*). The sample was taken at the Escuela Agrícola Panamericana and comprised 13 carrots about eight weeks from planting. These were washed with a brush, superficially dried, trimmed, and diced.

[1] A description for some of the foods has already been given in previous reports. This is indicated by a notation in parentheses following the name of the food, which identifies the reference by its series number, as shown in the opening paragraph of this report, and gives the name of the food with which the description appears.

HERBAGE VEGETABLES:

Apio (II and V, *Apio*). Six bunches of celery were obtained at the Escuela Agrícola Panamericana. This is probably the only place in Honduras where celery is grown. The stalks were small but of good quality. The bunches were separated and after being washed the stalks were left to drain. The leaves and tough parts of the stems were removed and the remainder chopped and mixed.

Bambusa arundinacea. Bamboo is native to Madagascar. Plants are being grown experimentally at Lancetilla, but it is not known to be grown elsewhere in Central America. At Lancetilla the Chinese cook used it in chop suey with good results. The sample comprised four shoots 12 to 18 inches long and four inches at the base, probably representing two or three days' growth. The bracts were stripped from the terminal eight inches, until no color showed and only the very tender shoots remained. These were chopped.

Camote, puntas de (I and V, *Camote;* I, *Camote, hojas de*). The sample was made up of about 100 growing points of the Nancy Hall variety, from field crop plantings at the Escuela Agrícola Panamericana. The leaves were washed and dried superficially, then chopped and mixed.

Chaya (I, *Chaya*). *Chaya* is native from Mexico through Central America, probably mainly along the coast. It is grown primarily as an ornamental and is not known to be used as food. For the sample about 50 of the tender, young shoots were taken from small trees near the golf course in La Lima. For subsampling they were chopped and mixed.

Chipilín (II, *Chipilín*). In Honduras *chipilín* is said to be used only in soups. About 400 stems were purchased in the San Pedro Sula market. These were immature with no flowers showing. The terminal leaves and tender parts of stems were chopped for subsamples.

Coliflor (I, *Coliflor;* II, *Brocoli*). Six mature heads of cauliflower were obtained in the garden at the Escuela Agrícola Panamericana. They were chopped and mixed for subsampling.

Kale, hojas de. Kale is probably a cultigen originating somewhere along the shores of Europe. For the sample five mature plants, about three months old, were collected at the Escuela Agrícola Panamericana. Subsamples were prepared very soon after collection. The upper parts of the leaves were chopped together.

Lechuga (II, *Lechuga*). The sample represented a good-quality head lettuce. It comprised six mature heads, about two months from planting, collected at the Escuela Agrícola Panamericana. After removing the outer leaves until clean, undamaged leaves were reached, the heads were chopped and mixed for subsampling.

Madre de cacao (IV, *Madre de cacao*). The flowers of this tree are not used as food in Honduras as they are in other parts of Central America. For the sample a large number (thousands) of flowers were taken from one tree at Zamorano. These were covered with many small white mites which could not be removed. Flowers only were used for the stabilized samples, which were prepared within an hour of collection.

Remolacha, hojas de (V, *Remolacha*). The sample of beet tops was taken from the garden at Zamorano and comprised all undamaged leaves,

petioles, and leaf blades, from the eight beets used for the sample of roots. They were washed and dried superficially, then chopped and mixed.

Repollo chino (I, *Repollo chino*). When used in a mixed salad the whole leaf of the Chinese cabbage is generally used. When eaten as an uncooked vegetable the whole leaf or only the fleshy, crisp mid-rib may be eaten. Five mature heads, two months from planting, were taken for the sample. The outer leaves were removed until the exposed leaves were clean and tender. The heads were then chopped.

Yuca, hojas de (I, *Yuca blanca, hojas de*). The seven samples of growing points of yucca, representing seven varieties of this plant, were taken from the variety plots at Zamorano. Each sample comprised 50 to 100 pieces, each taken from a different plant. The stabilized samples were prepared within an hour of the time of collection.

Gnetum Gnemon. This tree is native to the Malayan area, where the leaves are said to be used as food. The sample comprised new leaves from one tree growing in the gardens at Lancetilla. After being washed and dried superficially the leaf blades were chopped and mixed.

FRUIT VEGETABLES:

Aguacate (I, *Aguacate*). Eight ripe fruits of the West Indian type of avocado were purchased in the market in La Lima. These fruits weighed about 240 gm. each and had shiny, thin, green skins and yellow-to-yellow-green, moist, rather soft flesh. The flesh, spooned from the shells, was mixed for subsampling.

Masapan. The breadfruit tree is native to the Malayan region, but is now distributed throughout the tropics. In some parts of the world, especially in the Polynesian area, it is an exceedingly important item of the diet. It is not yet common in Central America, although it is found occasionally in coastal areas. It is eaten boiled or fried, or boiled and then fried. The sample consisted of three immature fruits from one tree. These were pale green, not spiny, and had pure white flesh. For subsampling the fruits were cut longitudinally, peeled and cored, and the flesh cubed.

Pataste (I, *Pataste*). The sample of chayote consisted of eight mature, spineless, dark-green, deeply sulcated fruits. The flesh was very moist, firm, and greenish. The fruits were peeled and the flesh diced for subsampling.

Pimienta dulce (I and V, *Chile dulce*). Thirteen green peppers of the horticultural variety California Wonder were collected at the Escuela Agrícola Panamericana for the sample. They were washed and dried superficially, the stem and seeds were removed, and the flesh with skin was chopped.

Pipián (I and V, *Ayote*). The sample consisted of eight immature squash fruits purchased in the market at San Pedro Sula. These fruits were ovoid in form with green-striped skins and moist, pale-green flesh. A longitudinal wedge, including skin, flesh, and seeds, was cut from each fruit for each of the three stabilized samples.

Tomate verde (I and V, *Tomate*). Green tomatoes are used in stews and to flavor soups. The sample comprised nine medium-sized fruits selected at random from plants at the Escuela Agrícola Panamericana. They were firm and green with a little red beginning to show. The fruits were washed and a wedge taken from each one for the subsamples.

CEREALS:

Jilote (I, *Jilote*). Fifty very immature ears of corn, about three or four months from planting, were purchased in the market at San Pedro Sula. For subsampling the husks were removed and the cobs with young kernels chopped.

LEGUMES:

Gandul (I, *Gandul*). About 400 pods were taken for the sample. These came from plants grown for green fertilizer. The pods were well filled out but still tender. These peas were very hard to shell; it required one hour for one person to shell the sample.

Lablab. Lablab probably originated in India, where it seems to be native. It is an important food plant in India and tropical Africa and has been in cultivation for a long time. It is rarely cultivated in Central America, although it deserves consideration from several viewpoints. The plant is easily grown and seems to be relatively free from disease. It may be grown from sea level in the wet lowlands up to at least 3,000 feet in the relatively dry highlands. An abundance of fruits is produced. The immature pods may be used in stews or as a green vegetable, and the mature seeds are used much like peas. It might well take the place of garden peas in the tropics, where peas do not thrive except at high elevations. The plant also enriches the soil and when it no longer bears may be used as fodder. Both samples were taken from plants about three months old, grown at the Escuela Agrícola Panamericana for fertilizer. Sample (a) comprised beans shelled from about 200 pods and Sample (b) about 150 small, immature pods, including the very immature beans.

FRUITS:

1. BANANAS AND PLANTAINS:

Banano (I and V, *Banano*). All except one, Gros Michel (a), of the 26 samples of bananas were from the variety plot of the Tela Railroad Company near Lima. The exception was from a commercial plantation. All were held in the ripening room of the same company's Research Department and all were at or near optimum condition when sampled. Each sample comprised fruits from a single stem. The samples were prepared by mixing the flesh from a number of fruits taken from several hands. The sample of the Brazilian variety comprised four fruits of three hands. These were rather short and had yellow, slightly flecked skins, and white, slightly acid flesh. The sample of Bungulan also comprised four fruits from each of three hands. These were also rather short, with good yellow skins and very pale-yellow flesh of fair flavor, but drier than the Gros Michel. Four fruits from three hands were also taken for the sample of Cavendish. These bananas were rather small with thick, yellow-flecked skins and very pale, fairly moist flesh of good flavor.

The variety Choui Can Trang is a small Champa type banana from French Indo China. Fifteen fruits, five from each of three hands, were taken for the sample. These were very short and stout with thin, yellow skins flecked with small brown spots. The flesh was very pale-yellow, moist, and rather sweet. For the sample of Congo, three fruits were taken

from each of three hands. This banana is similar to the Gros Michel. The Dorado is a small Champa or lady finger banana originating in Cuba. The sample included 21 fruits, seven from each of three hands. The skins were thin, yellow, and lightly flecked; the flesh was very pale-yellow, almost white, fairly sweet, and somewhat dry. Four fruits from each of three hands were taken for the sample of Grande Nain. This is a medium-sized banana with fairly thick skin. The flesh is pale, moist, and of fine flavor.

For Sample (a) of Gros Michel 12 fruits were taken from two hands. These were of average size and flavor with very pale, moist flesh. Sample (b) comprised nine fruits, three from each of three hands. These were somewhat shorter and thicker than those of Sample (a) and the skins were more greenish-yellow. Four fruits from each of three hands made up the sample of Guyuran. These were short and thick with cream-colored, moist, sweet flesh of good flavor. For the sample of Inarnibal, five bananas were taken from each of three hands. These fruits were of the Champa type. The skins were thin and lightly flecked; the flesh was rather sweet, moist, and very pale yellow. The Indiana is a rather short, thick banana. The cream-colored, moist flesh is of not very good flavor. Three fruits from each of three hands made up the sample of Kanara. These were relatively large, thick bananas with very moist, pale-orange-to-yellow flesh. The Kapas is a small, short fruit with thin skin, originating in the Federated Malay States. Twenty-four ripe fruits from the middle of the stem were taken for the sample. The moist flesh was almost white and of only fair flavor.

The sample of Kau Chiao consisted of four fruits from each of three hands. The stem from which these were taken was large and the individual fruits were relatively large. The skins were heavily flecked and the flesh was very pale-yellow, quite moist, and of fair flavor. The Lidi is a lady finger type banana, small and slender. Four fruits from each of four hands were taken for the sample. These had thin skins and pale, moist, fairly sweet flesh. The Masak Sahari is a rather slender banana. Six fruits from each of three hands made up the sample. The skins were a clear yellow and the flesh was pale-yellow, moist, and faintly acid in taste but of good flavor. Four fruits from each of three hands made up the sample of Morado Pula, a red banana originating in the Philippine Islands. The fruits were short and thick, with thin, reddish skins and pale, quite moist, sweet flesh.

The Morado Puti is a short, thick banana with thick yellow skin and pale, moist flesh of fair flavor. Three fruits from each of three hands were taken for the sample. Fruits of the Morong Datu are rather small, long, and slender. They do not ripen well or evenly. Four fruits from each of three hands comprised the sample. These had pale-yellow-greenish, rather thin skins, lightly flecked, and flesh of fair flavor, rather "tangy" and somewhat too firm. The Mundan, originating in the Federated Malay States, is another Champa type banana with small, short, thick fruits. Five fruits from each of three hands made up the sample. These had thin, yellow, flecked skins and pale-yellow, moist, rather sweet flesh. The Pomme Java, place of origin French Indo China, is an apple banana type.

Four fruits from each of three hands were taken for the sample. These had thin yellow skins and very nearly white, moist flesh of fair flavor.

Fruits of the Susu variety are very short and thick. Three fruits from each of three hands made up the sample. These had yellow skins beginning to fleck, and pale-cream, moist, fairly sweet flesh. Fruits of the Tadiao variety were longer and less thick than the Susu. The skins are thick and the flesh is pale-cream, moist, and not of pleasing flavor. Three fruits from each of three hands made up the sample. The Tumoc variety of banana resembles the Gros Michel in appearance and taste. Three fruits from each of three hands were taken for the sample. The Vimana, place of origin New South Wales, is a slender banana with a rather heavy peel. Four fruits from each of three hands were taken for the sample. The flesh was almost white, moist, and of good flavor.

Plátano. The two samples of plantains came from the variety plot of the Tela Railroad Company near La Lima and the stems were ripened in the ripening room of the Research Department of the company. Two fruits from each of three hands made up the sample of Dominican Dwarf. These were rather large, angled fruits with yellow, relatively thin peels and pale-cream, firm, moist flesh of fair flavor. The sample of Laknan also comprised two fruits from each of three hands. These were a small, angled plantain with relatively thin skin and moist, white flesh of not too good flavor when raw.

2. OTHER:

Aberia (I, *Aberia*). This fruit is native to India and Ceylon; hence the name Ceylon gooseberry. About 200 fruits were collected at random from the plantation at Zamorano. For subsampling the calyces were removed and the whole fruits mashed and mixed.

Bandaria. This fruit is native to the Malayan area. It may be eaten raw or made into jam. The unripe fruits may be mixed with other food. The fruit is practically unknown in Central America and, therefore, is of little importance in the diet. The fruits are quite acid and probably would not find favor with Latin peoples. The sample was collected in the Experimental Garden at Lancetilla, from trees about 20 years old, and comprised 44 tree-ripe fruits. These were ovoid in form, measuring four by five cm., and pale-apricot in color. The flesh was moist, of apricot color, and had some fiber. The flesh and thin skin were cut away from the seed and mixed for subsampling.

Carambola (I, *Carambola*). The carambola tree is of Asiatic origin, but is now widely distributed in the tropics. The fruit may be used either green or ripe. Green, it is used in preserves or pickles, and ripe, it may be eaten out of hand or after stewing. Thirty tree-ripe fruits, collected at Lancetilla, made up the sample. These were about eight by four cm., five-winged, and pale-yellow-green in color. The skins were very thin. For subsampling cross sections of the skin and flesh were used. The seeds were discarded, although they are usually eaten.

Grumichama. This tree is thought to be native to Peru. Specimens are being cultivated in the Experimental Garden at Lancetilla, but it is not known to be cultivated elsewhere in Central America. The fruits may be

eaten out of hand or made into jelly. The sample comprised about 150 small, ripe fruits taken from a tree at Lancetilla. These had deep-red or purple skins and moist, white flesh of fair flavor. For subsampling, after the calyces and seeds were removed, the skin and flesh were chopped together.

Icaco (I, *Icaco*). The icaco is a shrub or small tree native along the seashore from Mexico to Panama, in the West Indies, Florida, and northern South America. As it grows wild it forms an important part of coastal thickets. It is occasionally, though not often, planted for its fruits. The fruits are small, less than an inch to one and a half inches in diameter, with thin skins varying from pink to black; the flesh is white, rather spongy, and insipid. The sample consisted of about 100 ripe fruits purchased in a market in La Lima. These were washed and dried, the peel and flesh cut away from the seed and mixed.

Madroño. This plant is native to northern South America and Panama but only cultivated specimens have been seen elsewhere in Central America. About 60 fruits were collected at Lancetilla for the sample. These were lemon-yellow-to-green in color and had a thick, rough rind. The inner portion around the seed is the part eaten. This white, moist material is somewhat acid but sweet. For subsampling, the fleshy covering of the seed was removed from the several fruits and mixed.

Pera (III, *Pera*). The sample comprised six fruits purchased in a market in San Pedro Sula. The peel was hard and greenish; the flesh was white. They were peeled and cored and the flesh was then diced.

Piña azucarón (I and V, *Piña*). Four ripe pineapples of about two kilos each were purchased in La Lima for the sample. They had been taken from the plants that day and were about 18 months from planting. The fruits were cut in half lengthwise, one-half of each peeled and cored, and then cut into small cubes for subsampling.

Yuyuga. This tree is probably native to India and possibly in adjacent tropical and subtropical regions. The natives of the north coast of Honduras claim it is native there, which doubtless means it has become spontaneous in some places. The sample, from a market in La Lima, comprised about 100 ripe pale-green-to-yellow-green fruits. The flesh was white, rather moist but firm, and quite sweet. The fruits were washed and the flesh with the thin skin cut from the seed and mixed.

Astrocarium Standleyanum. This palm is native to Panama, where it is common as a forest tree in the central part of the Canal Zone. The fruits are said to be used occasionally as food. One raceme of about 50 fruits was obtained at Lancetilla. Both the skin and flesh were deep-orange and the flesh was moist. The skin and flesh of each fruit were cut from the seed and mixed.

Elaeocarpus serratus. This tree is native to the East Indies and Malaya. In Central America it is not abundant enough to be of any importance. The fruits of this species are said to be pickled and used much like olives. Fruits of several species of the genus are eaten. About 200 small fruits, two by 2.5 cm., were taken from a tree at Lancetilla. They were unripe, green in color with thin skins, and with firm, fairly moist flesh. The flesh and skin of the fruit were cut from the seed and mixed.

Mangifera odorata. This species of the mango is native to the Malayan region. So far as is known, the trees at Lancetilla are the only ones in Central America. It is inferior to the ordinary mango; the fruits have a strong flavor and ripe fruits have an unpleasant odor. The fruits are eaten as a fruit out of hand. The sample, collected at Lancetilla, included fruits weighing about one pound, picked green and ripened three days. The skins were still green; the flesh was apricot color, very moist, and had an odor and flavor much like that of the Durian (I, *Durio*). The two faces were cut from the fruits, the flesh scooped out of the shells and mixed.

Noronhia emarginata. This tree is native to Madagascar. The fruit is eaten but is of little value. The trees at Lancetilla are probably the only ones in Central America. About 150 ripe fruits from one tree made up the sample. The fruits were small, about 2.5 by 2.5 cm., and had a thin, pale-cream, very moist layer of flesh. For subsampling, the thick shells were removed and the flesh and juice scraped from the seed. About 128 gm. were obtained.

Sandoricum indicum. This tree is native to the Malayan area. The fruits are eaten but are not greatly appreciated. Fifty tree-ripe fruits were collected at Lancetilla. These were oblate spherical in shape, about five by six cm., and had thick yellow peel. The flesh is the aril surrounding the large seed. This is white and acid to taste. The arils, mostly juice, were used in the subsamples.

DRY SAMPLES:

CEREALS:

Arroz (III, *Arroz*). The samples of *arroz* and of *arroz del país* were purchased in a market in Tegucigalpa. The first sample was second-grade rice. Each sample was ground before subsampling.

Maicillo (IV, *Maicillo*). The sample was purchased in Tegucigalpa and was ground for subsampling.

Maíz. The sample of *maíz blanco* (a), purchased in San Pedro Sula, was a white dent corn of the coastal type. The sample of *maíz blanco* (b), obtained in Tegucigalpa, was a white corn. This was heavily infested with weevils. *Maíz sabanero* was yellow corn, also purchased in Tegucigalpa. All samples were ground for subsampling.

LEGUMES:

Cacahuete (IV, *Maní*). Unroasted peanuts were purchased in Tegucigalpa. Analyses were made on subsamples prepared with and without hulls.

Frijol (I, *Habichuela*). The sample of *frijol colorado* consisted of medium-sized red beans; *frijol del país* (a) of small dark-red beans; and *frijol del país* (b) of small red beans somewhat lighter in color than the preceding sample. The first sample was purchased in Tegucigalpa and the other two in San Pedro Sula. All were ground for subsampling.

MISCELLANEOUS:

Café (III, *Café*). The sample of coffee represents one of the better types grown in Honduras. It was grown and collected in Güinope. The unroasted berries were ground for subsampling.

Engorda cavallo. This leguminous plant is native to Central America, where it is known as *engorda caballo.* It is cultivated for stock feed, but probably has little potentiality as food for human consumption. The sample was collected at the Escuela Agrícola Panamericana, Rio Yeguare Valley, where it is grown for stock feed. The new terminal growths of the shrub were used for the subsamples.

Palma africana de aceite. This palm is native to tropical Africa and is one of the most important economic plants of the continent. The oil has been in trade a great many years. The tree has doubtless been carried over much of Africa, and it is difficult to tell where the plant is native and where it has been introduced.

Cultivation of the African oil palm in Central America is on the increase. It is often planted in old banana lands, especially land that can no longer be used for bananas because of Panama disease. It offers a potentially valuable secondary crop for the lowland areas. Plants now operate for the extraction of the pericarp oil and production should increase as plantings are extended.

Two types of oil are obtained from the fruits—pericarp oil from the wall of the fruit and oil extracted from the kernel. Pericarp oil is the most easily extracted and was the first oil to enter into commerce under the name of palm oil. It is an edible oil, but it is also used in the manufacture of soap and similar products, and sometimes as fuel. The kernel oil is of greater value than pericarp oil, but much more difficult to extract. It is used for margarine manufacture and also for soap, candles, and other products.

The two samples of fruit of the African oil palm were taken from trees at the Lancetilla Experimental Garden. Sample (a) represents the palm known as the "Sumatra type" and Sample (b) the "Java type." For Sample (a) two inflorescences weighing about 80 lb. and with some thousands of ripe fruits were taken. For Sample (b) two inflorescences weighing about 100 lb. were used. The fruits of one were completely ripe and those of the other almost so.

For subsampling, about 50 fruits from each of the two heads were washed and cleaned, and the pericarp (skin and flesh) cut away from the seeds and mixed. The remaining fruits were used to obtain the respective oil samples. These were processed in the commercial plant of the Tela Railroad Company through the kindness of Dr. Reif, Chemist. The oils, representing pericarp oil, were not filtered.

RESULTS AND DISCUSSION

The data obtained from analyses of the 91 samples are shown (Table 2). Values are given for a number of foods which have not been reported upon previously in this study. These include *bambusa, hojas de "kale," hojas de remolacha,* and *Gnetum Gnemon* under Herbage Vegetables; *masapan* under Fruit Vegetables; *lablab* under Legumes; *bandaria, grumichama, madroña, yuyuga,* and the five samples not identified by Spanish names under Fruits; and all four samples listed as Miscellaneous. Three other foods have already been shown to have high nutritive values— *chaya,* Report I of the series; *chipilín,* Reports II and IV; and *maicillo,* Reports

IV and VI. The findings in regard to these foods and others of interest are discussed below.

As might be expected, the majority of the foods showing high values for several nutrients are among the herbage vegetables. *Puntas de camote* contained appreciable amounts of calcium (123.9 mg.), of iron (2.76 mg.), of riboflavin (0.312 mg.), and of ascorbic acid (77.6 mg.). *Chaya* gave relatively high values for calcium (134.1 mg.), iron (2.84 mg.), carotene (4.858 mg.), thiamine (0.194 mg.), riboflavin (0.264 mg.), and ascorbic acid (212.5 mg.). In some respects this sample was superior, and in others inferior, to the first sample examined. *Chipilín* gave high values comparable to those shown for other samples, calcium (190.0 mg), iron (4.28 mg.), carotene (6.851 mg.), thiamine (0.385 mg.), riboflavin (0.544 mg.), niacin (2.000 mg.), and ascorbic acid (98.2 mg.). The leaves of kale, *hojas de "kale,"* contained large amounts of calcium (299.8 mg), of iron (3.07 mg.), of carotene (5.448 mg.), of thiamine (0.191 mg.), of riboflavin (0.243 mg.), and of ascorbic acid (212.0 mg.). Beet leaves, *hojas de remolacha*, on the other hand, gave a significantly high value only for riboflavin (0.258 mg.).

Values for the seven samples of *hojas de yuca* may indicate varietal differences, although attention is first attracted to the consistent occurrence of high values for certain constituents, nitrogen (0.752 to 1.120 mg.), calcium (154.6 to 230.9 mg.), iron (1.29 to 2.59 mg.), riboflavin (0.219 to 0.348 mg.), niacin (1.505 to 2.000 mg.), and ascorbic acid (223.5 to 351.5 mg.).

The one sample of *Gnetum Gnemon* gave exceptionally high values for calcium (335.9 mg.), carotene (10.273 mg.), riboflavin (0.327 mg.), and ascorbic acid (215.0 mg.), with moderately high values for iron (2.71 mg.), thiamine (0.106 mg.), and niacin (1.479 mg.).

Breadfruit or *masapan*, the fruit vegetable not previously reported, seemingly makes no outstanding contribution to the diet.

The legume lablab is significant only in the content of nitrogen (1.345 mg.), thiamine (0.266 mg.), and niacin (2.006 mg.) in the mature bean.

The 26 samples of bananas are most remarkable in their uniformity of composition. The variation of greatest significance is in the ascorbic acid content (7.6 to 32.8 mg.).

Among the nine fruits reported for the first time, there are five that should be mentioned. One, *Astrocarium Standleyanum*, gave a very high value for carotene (14.898 mg.); four gave high values for ascorbic acid: *bandaria* (75.0 mg.), *yuyuga* (65.8 mg.), *Elaeocarpus serratus* (100.5 mg.), and *Sandoricum indicum* (86.0 mg.). Another fruit, *aberia*, also contained a large amount of ascorbic acid (102.5 mg.).

Kafir corn, *maicillo*, is outstanding among the cereals in its content of niacin (3.184 mg.).

The niacin content (18.400 and 16.400 mg.) of the peanut, *cacahuete*, again calls attention to the potential value of this food as a source of niacin, a nutrient especially important to maize-eating populations.

The fruit of the African oil palm apparently is very high in content of carotene (62.767 and 25.694 mg.), and contains relatively large amounts of iron (4.69 and 3.29 mg.) and thiamine (0.244 and 0.263 mg.); also sig-

TABLE 2

Composition of Food Samples From Honduras

Name of food sampled			Place of origin of sample	Constituents measured and yields per 100 gm.											
Spanish	Scientific	English		Moisture	Ether extract	Crude fiber	Nitrogen	Ash	Calcium	Phosphorus	Iron	Carotene	Thiamine	Riboflavin	Niacin	Ascorbic Acid-Total
				gm.	*gm.*	*gm.*	*gm.*	*gm.*	*mg.*	*mg.*	*mg.*	*mg.*	*mg.*	*mg.*	*mg.*	*mg.*
	EARTH VEGETABLES															
Malanga colorada	*Xanthosoma violaceum* Schott	Malanga	San Pedro Sula	61.1	0.17	0.6	.392	1.10	18.5	83.2	0.71	.007	.148	.038	.612	12.1
Rábano blanco	*Raphanus sativus* L.	Radish	San Juan Lindo	92.6	0.01	0.7	.154	.66	22.0	33.5	0.60	.004	.036	.026	.500	48.1
Remolacha	*Beta vulgaris* var. *crassa* Alef.	Beet	Zamorano	90.1	0.21	0.6	.224	.85	11.9	29.8	0.40	.000	.026	.029	.270	4.7
Zanahoria	*Daucus Carota* L.	Carrot	Zamorano	90.6	0.27	1.0	.221	1.20	36.3	61.9	0.54	.643	.065	.048	.997	9.2
	HERBACEOUS VEGETABLES															
Apio	*Apium graveolens* L.	Celery	Zamorano	92.9	0.20	0.8	.138	1.23	43.4	41.8	0.35	.015	.035	.060	.496	17.7
.....	*Bambusa arundinacea* Willd.	Bamboo sprouts	Lancetilla	90.7	0.23	0.5	.371	.72	32.5	40.9	0.43	.016	.148	.068	.606	4.2
Camote, puntas de	*Ipomoea Batatas* (L.) Lam.	Growing points of sweet potato plant	Zamorano	84.8	0.99	1.8	.608	1.54	123.9	32.0	2.76	.073	.104	.312	1.420	77.6
Chaya	*Cnidoscolus aconitifolius* (Mill.) I. M. Johnston	.....	La Lima	83.2	1.03	1.8	.666	1.52	134.1	70.8	2.84	4.858	.194	.264	1.118	212.5
Chipilin	*Crotalaria longirostrata* Hook. and Arn.	.....	San Pedro Sula	81.8	0.93	1.8	1.192	1.16	190.0	74.8	4.28	6.851	.385	.554	2.000	98.2
Coliflor	*Brassica oleracea* var. *botrytis* L.	Cauliflower	Zamorano	89.8	0.14	1.0	.369	.86	28.8	36.5	0.56	.011	.059	.085	.615	111.5
"Kale," hojas de	*Brassica oleracea* var. *acephala* DC.	Leaves of kale	Zamorano	82.1	1.22	1.3	.840	1.92	299.8	52.0	3.07	5.448	.191	.243	1.174	212.0
Lechuga	*Lactuca sativa* var. *capitata* Hort.	Lettuce	Zamorano	95.8	0.14	0.5	.160	.38	16.1	23.2	0.35	.000	.048	.034	.292	6.7
Madre de cacao	*Gliricidia Sepium* (Jacq.) Walp.	.....	Zamorano	86.3	0.22	2.0	.363	.63	26.2	36.1	1.05	.030	.085	.112	.600	43.5
Remolacha, hojas de	*Beta vulgaris* var. *crassa* Alef.	Beet tops	Zamorano	90.6	0.40	1.2	.442	1.93	90.8	33.8	2.02	.018	.073	.258	.523	58.0
Repollo chino	*Brassica pekinensis* (Lour.) Rupr.	Chinese cabbage	Zamorano	94.2	0.15	0.6	.251	.68	36.1	40.8	0.38	.000	.059	.037	.674	22.7
Yuca, hojas de (a)	*Manihot esculenta* Crantz.	Cassava leaves	Zamorano	80.2	1.09	2.1	1.075	1.56	171.5	94.0	2.59	.034	.151	.348	2.000	321.0
Yuca, hojas de (b)	*Manihot esculenta* Crantz.	Cassava leaves	Zamorano	79.3	1.16	2.4	1.120	1.51	169.0	80.3	2.13	.024	.113	.227	1.505	351.5

Yuca, hojas de (e)	*Manihot esculenta* Crantz.	Cassava leaves	Zamorano	78.1	1.13	2.3	1.113	1.75	220.8	102.2	1.97	.095	.123	.296	1.901	249.0
Yuca, hojas de (d)	*Manihot esculenta* Crantz.	Cassava leaves	Zamorano	78.0	1.16	2.5	1.015	1.63	161.1	82.4	2.30	.094	.114	.290	1.798	282.5
Yuca, hojas de (e)	*Manihot esculenta* Crantz.	Cassava leaves	Zamorano	77.4	1.08	2.8	.880	1.51	230.9	71.3	1.99	.098	.117	.266	1.624	223.5
Yuca, hojas de (f)	*Manihot esculenta* Crantz.	Cassava leaves	Zamorano	79.0	1.02	3.0	.752	1.60	187.4	80.4	1.43	.081	.130	.248	1.560	250.0
Yuca, hojas de (g)	*Manihot esculenta* Crantz.	Cassava leaves	Zamorano	82.2	0.96	2.5	.799	1.50	154.6	63.7	1.29	.056	.095	.219	1.545	318.0
.....	*Gnetum Gnemon* L.	.....	Lancetilla	65.6	2.23	11.8	.949	1.67	335.9	72.6	2.71	10.273	.106	.327	1.479	215.0
	FRUIT VEGETABLES															
Aguacate	*Persea americana* Mill.	Avocado	San Pedro Sula	78.6	12.72	1.3	.251	.46	9.2	39.4	0.54	.195	.057	.138	1.337	14.8
Masapan	*Artocarpus altilis* (Park.) Fosberg	Breadfruit	Lancetilla	79.3	0.14	1.4	.125	.56	25.4	24.8	0.61	.004	.085	.033	.506	24.5
Pataste	*Sechium edule* (Jacq.) Sw.	Chayote	La Cumbre de San Pedro Sula	92.4	0.11	0.5	.160	.45	14.6	33.1	0.29	.031	.033	.037	.469	17.0
Pimienta dulce	*Capsicum annuum* var. *grossum* (L.) Sendt.	Sweet pepper	Zamorano	93.7	0.24	0.7	.191	.34	6.1	18.5	0.43	.010	.038	.041	.596	100.5
Pipián	*Cucurbita Pepo* L.	Squash	Avenales	92.9	0.36	0.5	.173	.55	20.0	45.5	0.47	.008	.053	.050	.521	22.3
Tomate verde	*Lycopersicum esculentum* Mill.	Tomato, green	Zamorano	93.3	0.20	0.5	.185	.57	5.1	19.5	0.43	.018	.051	.039	.512	23.5
	CEREALS															
Jilote	*Zea Mays* L.	Green corn	Avenales	88.8	0.24	0.9	.290	.52	11.7	50.5	0.37	.010	.088	.090	.758	11.7
	LEGUMES															
Gandul	*Cajanus Cajan* (L.) Millsp.	Pigeon pea	Zamorano	65.4	0.70	5.8	1.266	1.31	37.2	95.8	1.33	.005	.344	.200	2.180	56.0
Lablab (a)	*Dolichos Lablab* L.	Lablab beans	Zamorano	65.8	0.53	2.7	1.345	1.12	25.6	121.1	2.14	.140	.266	.078	2.006	36.0
Lablab (b)	*Dolichos Lablab* L.	Lablab, immature pods	Zamorano	86.2	0.27	1.7	.493	.80	69.5	54.1	1.19	1.179	.090	.136	.906	28.9
	FRUITS															
	1. Bananas and Plantains															
Banano	*Musa paradisiaca* var. *sapientum* L.	Brazilian	Farm Guaruma No. 2	67.9	0.09	0.4	.167	.81	13.7	31.2	0.38	.067	.039	.034	.645	25.1
Banano	*Musa paradisiaca* var. *sapientum* L.	Bungalan	Farm Lima	69.1	0.08	0.4	.157	.92	9.5	27.2	0.35	.083	.042	.041	.551	11.9
Banano	*Musa paradisiaca* var. *sapientum* L.	Cavendish	Farm Lima	75.4	0.08	0.3	.193	.81	7.4	31.5	0.39	.042	.033	.053	.651	9.1
Banano	*Musa paradisiaca* var. *sapientum* L.	Choui Cau Trang	Farm Lima	70.3	0.03	0.4	.188	.83	4.4	22.5	0.42	.063	.036	.062	.620	12.3

TABLE 2 (*Continued*)

Composition of Food Samples From Honduras

Name of food sampled			Place of origin of sample	Constituents measured and yields per 100 gm.											
Spanish	Scientific	English		Moisture	Ether extract	Crude fiber	Nitrogen	Ash	Calcium	Phosphorus	Iron	Carotene	Thiamine	Riboflavin	Niacin	Ascorbic Acid-Total
				gm.	*gm.*	*gm.*	*gm.*	*gm.*	*mg.*	*mg.*	*mg.*	*mg.*	*mg.*	*mg.*	*mg.*	*mg.*
Banano	*Musa paradisiaca* var. *sapientum* L.	Congo	Farm Guaruma No. 1	73.4	0.03	0.3	.183	.82	6.9	24.2	0.48	.....	.039	.047	.718	10.1
Banano	*Musa paradisiaca* var. *sapientum* L.	Dorado	Farm Lima	72.2	0.02	0.7	.228	.95	11.7	30.5	0.43	.050	.052	.059	.752	12.0
Banano	*Musa paradisiaca* var. *sapientum* L.	Grande Nain	Farm Lima	74.8	0.03	0.3	.204	.89	7.2	23.9	0.34	.058	.033	.048	.679	9.1
Banano	*Musa paradisiaca* var. *sapientum* L.	Gros Michel	Farm Lima	73.2	0.09	0.3	.128	.89	9.1	27.0	0.36	.047	.024	.040	.562	8.9
Banano	*Musa paradisiaca* var. *sapientum* L.	Gros Michel	Farm Guaruma No. 1	74.6	0.02	0.2	.155	.83	6.4	30.5	0.41	.035	.034	.045	.703	9.8
Banano	*Musa paradisiaca* var. *sapientum* L.	Guyuran	Farm Guaruma No. 1	73.3	0.16	0.5	.195	.42	10.9	29.8	0.43	.006	.033	.036	.689	8.0
Banano	*Musa paradisiaca* var. *sapientum* L.	Inarnibal	Farm Lima	69.4	0.02	0.5	.180	.80	4.9	21.6	0.35	.111	.032	.059	.625	13.2
Banano	*Musa paradisiaca* var. *sapientum* L.	Indiana	Farm Guaruma No. 1	74.2	0.10	0.3	.193	.79	10.2	20.1	0.27	.085	.045	.047	.760	9.7
Banano	*Musa paradisiaca* var. *sapientum* L.	Kanara	Farm Guaruma No. 2	68.6	0.06	0.4	.171	.86	6.2	19.2	0.50	1.646	.039	.039	.475	13.1
Banano	*Musa paradisiaca* var. *sapientum* L.	Kapas	Farm Lima	75.0	0.08	0.3	.190	.88	10.1	29.8	0.31	.030	.032	.048	.557	7.8
Banano	*Musa paradisiaca* var. *sapientum* L.	Kau Chiao	Farm Lima	71.9	0.08	0.4	.157	.89	7.8	22.2	0.37	.042	.040	.055	.634	8.4
Banano	*Musa paradisiaca* var. *sapientum* L.	Lidi	Farm Guaruma No. 1	70.4	0.14	0.3	.217	.92	18.8	22.7	0.56	.067	.024	.039	.532	21.9
Banano	*Musa paradisiaca* var. *sapientum* L.	Masak Sabari	Farm Guaruma No. 2	73.6	0.06	0.3	.163	.87	9.0	24.0	0.38	.211	.045	.055	.574	11.9
Banano	*Musa paradisiaca* var. *sapientum* L.	Morado Pula	Farm Lima	74.4	0.10	0.3	.158	.84	10.8	18.8	0.27	.107	.032	.045	.516	7.6
Banano	*Musa paradisiaca* var. *sapientum* L.	Morado Puti	Farm Guaruma No. 1	73.1	0.09	0.4	.166	.80	14.1	20.1	0.62	.091	.037	.042	.593	11.6

Banano	*Musa paradisiaca* var. *sapientum* L.	Morong Datu	Farm Guaruma No. 2	71.3	0.11	0.4	.218	.99	17.2	27.3	0.51	.069	.069	.050	.638	32.8
Banano	*Musa paradisiaca* var. *sapientum* L.	Mundan	Farm Lima	70.9	0.03	0.4	.200	.85	8.0	24.8	0.31	.046	.028	.050	.634	12.1
Banano	*Musa paradisiaca* var. *sapientum* L.	Pomme Java	Farm Lima	70.6	0.06	1.6	.136	.80	5.0	38.4	0.20	.020	.038	.038	.535	19.1
Banano	*Musa paradisiaca* var. *sapientum* L.	Susu	Farm Guaruma No. 1	72.2	0.21	0.3	.173	.87	12.5	37.2	0.49	.018	.033	.054	.594	9.5
Banano	*Musa paradisiaca* var. *sapientum* L.	Tadiao	Farm Guaruma No. 1	73.0	0.19	0.3	.200	.82	11.8	22.9	0.29	.012	.043	.051	.647	13.0
Banano	*Musa paradisiaca* var. *sapientum* L.	Tumoc	Farm Guaruma No. 1	73.8	0.06	0.3	.172	.81	6.9	28.2	0.47	.059	.036	.044	.684	10.7
Banano	*Musa paradisiaca* var. *sapientum* L.	Vimana	Farm Lima	72.5	0.08	0.3	.153	.83	8.2	30.3	0.33	.043	.033	.054	.665	9.7
Plátano	*Musa paradisiaca* L.	Dominican Dwarf	Farm Lima	61.9	0.11	0.7	.154	.89	6.9	41.1	0.44	.494	.063	.038	.534	25.5
Plátano	*Musa paradisiaca* L.	Lakman	Farm Lima	65.1	0.08	0.8	.159	.90	4.9	31.2	0.32	.052	.049	.039	.438	14.1
	2. Other															
Aberia	*Doryalis hebecarpa* (Gardn.) Warb.	Ceylon gooseberry	Zamorano	81.9	0.64	1.7	.206	.61	13.3	24.5	0.91	.125	.017	.033	.316	102.5
Bandaria	*Bouea macrophylla* Griff.	Bandaria	Lancetilla	85.2	0.04	0.6	.112	.23	6.0	10.8	0.31	.043	.031	.025	.286	75.0
Carambola	*Averrhoa Carambola* L.	Star apple	Lancetilla	91.0	0.09	0.9	.073	.36	4.4	15.5	0.32	.552	.038	.019	.294	26.0
Grumichama	*Eugenia Dombeyana* DC.	.....	Lancetilla	85.3	0.29	0.6	.102	.43	39.5	13.6	0.45	.039	.044	.031	.336	18.8
Icaco	*Chrysobalanus Icaco* L.	Icaco	Tela	86.4	0.00	1.2	.062	.84	30.5	10.3	0.38	.007	.048	.027	.233	9.2
Madroño	*Rheedia Madruno* Planch. and Triana	Madrono	Lancetilla	86.1	0.05	1.0	.086	.18	13.8	22.8	0.39	.003	.065	.038	.254	5.5
Pera	*Pyrus communis* L.	Pear	Siguatepeque	88.9	0.13	1.4	.043	.24	6.4	7.6	0.21	.003	.017	.013	.149	6.3
Piña azucarón	*Ananas comosus* (L.) Merrill	Pineapple	La Cumbre de San Pedro	81.3	0.05	0.4	.098	.31	12.6	7.8	0.34	.027	.138	.037	.244	42.3
Yuyuga	*Zizyphus jujuba* Lam.	Jujube	San Pedro	83.0	0.07	0.6	.284	.59	25.6	26.8	0.76	.021	.024	.038	.873	65.8
.....	*Astrocarium Standleyanum* Bailey	.....	Lancetilla	71.9	0.67	5.7	.269	1.41	62.1	41.0	1.50	14.898	.057	.072	.536	3.5
.....	*Elaeocarpus serratus* L.	.....	Lancetilla	74.2	0.09	3.1	.169	.74	43.7	36.1	1.57	.183	.019	.012	.453	100.5
.....	*Mangifera odorata* Griff.	.....	Lancetilla	79.9	0.06	0.8	.145	.60	4.4	17.9	0.22	.388	.042	.060	.734	13.1
.....	*Noronhia emarginata* Thou.	.....	Lancetilla	78.0	0.00	0.6	.087	.44	18.6	33.9	0.60	.011	.042	.039	.712	6.0
.....	*Sandoricum indicum* Ridl.	Santol	Lancetilla	87.0	0.10	0.1	.118	.31	4.3	17.4	0.42	.003	.045	.026	.741	86.0

TABLE 2 *(Concluded)*

Composition of Food Samples From Honduras

Name of food sampled			Place of origin of sample	Constituents measured and yields per 100 gm.											
Spanish	Scientific	English		Moisture	Ether extract	Crude fiber	Nitrogen	Ash	Calcium	Phosphorus	Iron	Carotene	Thiamine	Riboflavin	Niacin	Ascorbic Acid-Total
	DRY SAMPLES			*gm.*	*gm.*	*gm.*	*gm.*	*gm.*	*mg.*	*mg.*	*mg.*	*mg.*	*mg.*	*mg.*	*mg.*	*mg.*
	Cereals															
Arroz	*Oryza sativa* L.	Rice	Santa Barbara	10.6	0.43	0.7	1.343	.41	6.1	92.4	0.98	.004	.099	.037	1.458	.....
Arroz del país	*Oryza sativa* L.	Rice	Danlí	12.4	0.87	1.2	1.342	.45	5.8	103.0	0.64	.003	.057	.031	1.686	.....
Maicillo	*Sorghum vulgare* Pers.	Kafir corn	Comayagua	11.4	2.43	1.8	1.514	1.49	15.1	302.0	3.32	.014	.505	.083	3.184	.....
Maíz blanco	*Zea Mays* L.	Corn	San Pedro Sula	13.2	4.66	2.0	1.577	1.43	6.1	331.0	2.33	.012	.529	.089	2.176	.....
Maíz blanco	*Zea Mays* L.	White corn	Rio Abajo	9.6	4.20	2.0	1.658	1.33	5.6	295.5	2.07	.012	.522	.075	2.192	.....
Maíz sabanero	*Zea Mays* L.	Yellow corn	Curarén	9.8	3.94	1.7	1.457	1.39	6.8	315.5	1.99	.072	.459	.072	2.098	.....
	Legumes															
Cacahuete	*Arachis hypogaea* L.	Peanut, with skin,	Danlí	5.0	54.2	2.3	5.115	2.48	83.0	472.0	2.87	.020	.644	.106	18.400	.....
		without skin	Danlí	5.7	52.2	1.6	5.186	2.48	68.2	495.5	1.99	.012	.810	.102	16.400	.....
Frijol colorado	*Phascolus vulgaris* L.	Small red bean	Rio Abajo	11.3	1.29	4.8	4.042	3.66	143.3	378.0	6.80	.017	.604	.151	2.280	.....
Frijol del país	*Phascolus vulgaris* L.	Small red bean	San Juan Lindo	15.9	1.35	4.7	4.234	3.72	113.4	432.0	7.79	.014	.523	.157	1.773	.....
Frijol del país	*Phascolus vulgaris* L.	Small red bean	San Juan Lindo	17.3	0.75	4.5	3.609	3.58	107.5	430.0	7.47	.013	.456	.141	2.120	.....
	MISCELLANEOUS															
Café	*Coffea arabica* L.	Coffee	Güinope	6.3	6.29	30.0	2.372	3.57	94.4	165.0	3.91	.008	.259	.101	1.294	.....
Engorda caballo	*Desmodium Cinereum* (HBK.) DC.	A shrub	Zamorano	74.1	1.83	6.1	.930	1.79	227.2	107.5	3.79	4.056	.254	.113	1.464	164.1
Palma africana de aceite (a)	*Elaeis guineensis* Jacq.	Fruit of African oil palm	Lancetilla	26.4	61.65	2.1	.258	.87	107.0	51.6	4.69	62.767	.244	.126	1.078	7.8
Palma africana de aceite (b)	*Elaeis guineensis* Jacq.	Fruit of African oil palm	Lancetilla	29.6	56.20	3.3	.237	.86	87.5	36.1	3.29	25.694	.263	.113	1.558	10.1
Palma africana de aceite, aceite de	*Elaeis guineensis* Jacq.	Oil of fruit of African oil palm	Lancetilla	0.9	99.05	0.0	.014	.08	14.6	10.8	12.29	35.296	.003	.011	.000	.....
Palma africana de aceite, aceite de	*Elaeis guineensis* Jacq.	Oil of fruit of African oil palm	Lancetilla	0.2	99.89	0.0	.028	.04	5.0	6.5	6.06	30.841	.005	.012	.000	.....

nificantly large amounts of calcium (107.0 and 87.5 mg.) and niacin (1.078 and 1.558 mg.). The pericarp oil expressed from these fruits is also high in content of carotene (35.296 and 30.841 mg.).

The cattle food, *engorda cavallo*, gave high values for calcium (227.2 mg.), iron (3.79 mg.), carotene (4.056 mg.), thiamine (0.254 mg.), and ascorbic acid (164.1 mg.).

SUMMARY

In the first report of this series on the composition of food plants of Central America, Munsell *et al.* (1949), results were presented from the analyses of 121 samples of food plants collected in Honduras. During the period from November, 1946 to August, 1948 an additional 91 samples were collected in this country. Twenty-four of these were obtained at the Escuela Agrícola Panamericana, 16 from the Lancetilla Experimental Gardens, and 29 from gardens of the Tela Railroad Company. The remaining 22 samples were purchased in markets. All samples were analyzed for content of moisture, ether extract, crude fiber, nitrogen, ash, calcium, phosphorus, iron, carotene, thiamine, riboflavin, niacin, and ascorbic acid. These data are presented as the seventh in a series of reports on the composition of foods of Central America.

A number of the foods studied had not been shown in lists of previous reports from this laboratory. Among the herbage vegetables were: *bambusa* with no outstandingly high values; *hojas de "kale"* with high values for calcium, iron, carotene, thiamine, riboflavin, and ascorbic acid; *hojas de remolacha* with high values for thiamine and riboflavin; and *Gnetum Gnemon* with exceptionally high values for calcium, carotene, riboflavin, and ascorbic acid, and moderately high values for several other nutrients. *Masapan*, a fruit vegetable, was mediocre in its nutrient content. The mature beans of the legume lablab contained appreciable amounts of nitrogen, thiamine, and niacin.

Of the nine fruits not mentioned previously five are of interest: *Astrocarium Standleyanum* with a very high value for carotene; *bandaria, yuyuga, Elaeocarpus serratus*, and *Sandoricum indicum* with high values for ascorbic acid.

Fruits of the African oil palm were shown to be rich in carotene and to be good sources of calcium, iron, thiamine, and niacin.

A cattle food, *engorda cavallo*, comprising terminal leaves and growing points of a shrub, gave outstanding values for calcium, iron, carotene, thiamine, and ascorbic acid.

Attention is again called to the high niacin content of Kafir corn and raw peanuts.

Values are shown for 26 samples of bananas and two of plantains. These fruits are remarkable in their uniformity of composition.

Chaya and *chipilín* are again shown to be foods with high nutritive values.

ACKNOWLEDGMENT

This investigation was supported by a grant from the United Fruit Company to the Central American Nutrition Foundation, and was con-

ducted jointly by the Massachusetts Institute of Technology and the Escuela Agrícola Panamericana, Dr. Wilson Popenoe, Director.

REFERENCES

MUNSELL, H. E., WILLIAMS, L. O., GUILD, L. P., TROESCHER, C. B., NIGHTINGALE, G., AND HARRIS, R. S., 1949. Composition of food plants of Central America. I. Honduras. Food Research **14**, 144-164.

———, ———, ———, ———, ———, AND ———, 1950a. Composition of food plants of Central America. II. Guatemala. Food Research **15**, 16-33.

———, ———, ———, ———, ———, AND ———, 1950b. Composition of food plants of Central America. III. Guatemala. Food Research **15**, 34-52.

———, ———, ———, ———, ———, KELLEY, L. T., AND HARRIS, R. S., 1950c. Composition of food plants of Central America. IV. El Salvador. Food Research **15**, 263-296.

———, ———, ———, ———, AND HARRIS, R. S., 1950d. Composition of food plants of Central America. V. Nicaragua. Food Research **15**, 355-365.

———, ———, ———, KELLEY, L. T., MCNALLY, A. M., AND HARRIS, R. S., 1950e. Composition of food plants of Central America. VI. Costa Rica. Food Research **15**, 379-404.

COMPOSITION OF FOOD PLANTS OF CENTRAL AMERICA. VIII. GUATEMALA

HAZEL E. MUNSELL, LOUIS O. WILLIAMS, LOUISE P. GUILD, LUCILLE T. KELLEY, ANN M. McNALLY, AND ROBERT S. HARRIS

Nutritional Biochemistry Laboratories, Massachusetts Institute of Technology, Cambridge, Massachusetts

[Received for publication, May 20, 1950]

This report is the last in a series of eight, covering results from studies carried out in these laboratories and in the field, for the purpose of obtaining data on the composition of the edible plants of Central America. The first samples for these studies were collected in Honduras in July, 1946, and the last in Guatemala, in July, 1949. The first seven reports show data as follows: I, for 121 samples from Honduras, Munsell, Williams, Guild, Troescher, Nightingale, and Harris (1949); II, for 124 samples of vegetables from Guatemala, Munsell, Williams, Guild, Troescher, Nightingale, and Harris (1950a); III, for 106 samples, including 60 of fruits, from Guatemala, Munsell, Williams, Guild, Troescher, Nightingale, and Harris (1950b); IV, for 194 samples from El Salvador, Munsell, Williams, Guild, Troescher, Nightingale, Kelley, and Harris (1950c); V, for 51 samples from Nicaragua and four from Panama, Munsell, Williams, Guild, Troescher, and Harris (1950d); VI, for 154 samples from Costa Rica, Munsell, Williams, Guild, Kelley, McNally, and Harris (1950e); and VII, for 79 samples from Honduras, Munsell, Wlliams, Guild, Kelley, and Harris (1950f). The data shown in this report are for 79 samples obtained in Guatemala, 48 in January and February, 30 in July, 1949, and one *(hongo de San Juan)* in June, 1947.

A description of the procedure followed in the collection and preparation of samples for shipment, and an outline of the information recorded on the accompanying data sheets, were given in the first report of this series. Kodachromes were taken in duplicate of all samples, as has been done throughout the study; one set to be kept on file at the Escuela Agrícola Panamericana and the other in the M.I.T. Nutritional Biochemistry Laboratories. Specimens were also taken for the herbarium at the Escuela.

Methods of analysis used have been described in Reports I and II. The same 13 constituents were measured as shown in the first seven papers.

Of the 79 samples analyzed, 78 were purchased in markets, 73 in the several markets in Guatemala City, and five in Antigua. The remaining sample, *apio*, was taken from the ground at the Escuela Nacional de Agricultura near Bárcena. Information on altitude, prevailing soil type, and estimated annual rainfall in the areas where samples originated is summarized in Table 1. It should be noted that the majority of the samples came from the highland areas, where the soil is of volcanic origin.

EARTH VEGETABLES:

Ajo (VI, *Ajo*). About 100 mature bulbs, purchased in Antigua, made up the sample of garlic. The bulbs were broken into their separate cloves,

TABLE 1

Areas Where Samples Originated, With Information on Altitude, Prevailing Soil Type, and Estimated Annual Rainfall

Town	Department	Altitude	Soil type	Estimated rainfall	No. of samples
		ft.		*in.*	
Almolonga	Quezaltenango	7,400	Volcanic	70	1
Amatitlán	Guatemala	3,500	Volcanic	70	2
Antigua	Sacatepéquez	5,000	Volcanic	70	13
Atitlán	Sololá	5,000-6,000	Volcanic	70	2
Cerritos	Santa Rosa	0	Silt or gravel	60	1
Chichicastenango	Quiché	5,000	Volcanic	70	1
Ciudad Vieja	Sacatepéquez	5,000	Volcanic	70	1
Cobán	Alta Verapaz	4,000	Volcanic	100	1
Bárcena—Escuela Nacional de Agricultura	Guatemala	5,000	Volcanic	70	1
Escuintla	Escuintla	2,000	Volcanic	70-80	6
Guatemala	Guatemala	5,000	Volcanic	70	9
Jutiapa	Jutiapa	3,500	Volcanic	....	1
Mariscal—Farm Copalché	Guatemala	5,000	Volcanic	....	1
Mazatenango	Suchitepéquez	1,200	Volcanic	....	1
Morán—near Antigua	Sacatepéquez	5,000	Volcanic	....	1
Palencia	Guatemala	6,000	Volcanic	70	1
Near Palin	Escuintla	3,000	Volcanic	70	1
Panajachel	Sololá	5,000	Volcanic	....	1
Rabinal	Baja Verapaz	3,000	Alluvial from volcanic	....	1
El Rancho	El Progreso	600	Volcanic	....	1
San Augustín	El Progreso	700	Old volcanic	50	1
San Agustín de Zacapa	Zacapa	700	Volcanic	....	1
San Antonio—near Antigua	Sacatepéquez	5,000	Volcanic	....	1
San Bartolo	Sacatepéquez	6,000	Volcanic	70	1
San Bartolomé	Sacatepéquez	5,000-6,000	Volcanic	....	2
San José	Escuintla	0-100	Outwash plain	40	4
San José Pinula	Guatemala	5,500	Volcanic	....	1
San Juan Sacatepéquez	Guatemala	5,000-6,000	Volcanic	70	3
San Lucas	Sacatepéquez	7,000	Volcanic	70	3
San Pedro Ayumpac	Guatemala	6,000	Volcanic	70	1
Santa María del Volcán de Agua	Sacatepéquez	7,000	Volcanic	....	1
Santa María de Jesús	Sacatepéquez	7,000	Volcanic	....	1
Near Santiago	Sacatepéquez	5,000	Volcanic	70	1
Santiago Sacatepéquez	Sacatepéquez	6,500	Volcanic	70	4
Sololá	Sololá	6,000	Volcanic	70	1
Zacapa	Zacapa	600-700	Volcanic; sandy	50	6

from which the loose sheaths were removed. Subsamples were taken from the mixed cloves.

Camote (I and V, *Camote*). Six rather small roots of sweet potato made up the sample. These were firm with very pale or rose-tinted flesh. The roots were peeled and diced for subsampling.

Cebolla morada (I, IV, and V, *Cebolla*). The sample consisted of onions of good quality. They had purple skins and in some this color extended throughout the outer layers of flesh. The bulbs were peeled and diced.

Nabo (II and VI, *Nabo*). Twelve fair-sized turnips with firm, white, fairly moist flesh were purchased for the sample. These were peeled and diced for subsampling.

Salsifí (II and VI, *Salsifí*). About 70 small, mature roots were scraped and diced.

HERBAGE VEGETABLES:

Apio (II and VI, *Apio*). Sample (a) of celery comprised 24 small bunches. These were quite solid. Five mature, green bunches taken from the ground at the Escuela Nacional de Agricultura made up Sample (b). For subsampling, the leaves and roots were removed, the stems washed and dried, and then diced.

Bledo (II, *Bledo*). This plant, one of the Amaranths, is probably native to Central America. It is very common throughout Guatemala from the highlands to the coast, and especially in cultivated fields in the highlands at the beginning of the rainy season, when it is much used as food. It is not very common in markets, probably because it is so plentiful in the fields. The sample comprised about 500 young plants about four inches tall. They were washed and dried and the tender leaves and stems chopped for subsampling.

Brusela (II, *Brusela*). About 200 mature little heads made up the sample of Brussels sprouts. These were cleaned, trimmed, and chopped.

Busnay. This plant is native from Guatemala to Panama in moist or wet forests. It is a minor food plant, although the fleshy and immature inflorescences are prized as food. They are not common in markets and when seen are quite expensive. They are used in soups, or boiled and then fried in egg batter. The sample comprised about 100 immature inflorescences at a stage to use. The spathes were removed and the inflorescences then chopped and mixed.

Chanchón (I, *Repollo chino*). Six bunches of Chinese cabbage were purchased. They were rather small and tender. The fleshy midvein only was used. This was taken out, washed and dried superficially, and then chopped.

Coliflor (I, *Coliflor* and VI, *Brocoli*). Seven small heads of cauliflower in fine condition were trimmed and the usable part chopped.

Colinabo (I, *Colinabo*). Sample (a) of kohlrabi, purchased in February, consisted of 18 mature stems and Sample (b), purchased in July, of 24 small, tender, very pale-green stems. The stems only of both samples were peeled and diced for subsampling.

Culantro. Coriander is native to the Mediterranean region and is now naturalized over much of the world. In Central America the vegetative

parts of the plant are used as flavoring for other foods, especially those foods cooked in water. The sample comprised 200 plants at the flowering stage. The upper parts, stems, leaves, and flowers, were chopped.

Epasote. This member of the goosefoot family is native from the United States and Mexico to Panama. It is naturalized and possibly also cultivated in many other parts of the world. The plant has an unpleasant odor, but the vegetative parts are used as flavoring for beans and soups, and possibly also as a green. It is said to be used as a sedative and to expel intestinal parasites. In commerce the seeds are known as Mexican wormseed. About 150 young plants were trimmed, washed, superficially dried, and the tender leaves and stems chopped.

Espinaca fina (VI, *Espinaca de Victoria*). The sample comprised about 200 small, tender, very immature spinach plants. These were washed and left to drain one hour. The leaves were then removed and chopped.

Espinaca china. The corn marigold is native to Europe, Africa, and western Asia and is now dispersed as a cultivated plant or weed throughout much of the world. It seems to occur in Guatemala as a weed and is probably used rarely as food, although the Indian woman from whom the sample was purchased in Guatemala City said it was used like spinach. About 100 plants just before the flowering stage made up the sample. The plants were trimmed, washed and superficially dried, and then chopped.

Guicoy, puntas de (I and V, *Ayote*). About 50 tender growing points of squash were purchased. This material was washed and superficially dried and the tender tendrils, leaves, and stems chopped.

Hierba San Nicolás. This member of the Portulacaceae is native to Mexico and Guatemala, but apparently is not known elsewhere in Central America. It is said to be not uncommon in the highlands of Guatemala, where it is used like spinach, but is not commonly found in markets. About 50 plants were cleaned and the good leaves and terminal parts of stems chopped.

Izote, flor de (II, *Izote, Flor de* and VI, *Itabo, Flor de*). Three rather small inflorescences were purchased in the Indian market, Guatemala City. These were washed and dried superficially and the petals were taken from the flowers and mixed for subsampling.

Loroco (IV, *Loroco*). A large number of greenish-white flowers, undoubtedly from wild plants, made up the sample. The odor is very disagreeable, but in spite of this they are used in egg dishes, in soups, and in tamales. The flowers were washed before subsampling.

Malva. This member of the mallow family is native to Europe, from whence it has been introduced into much of the world. In the highlands of Central America it is found, occasionally and sometimes abundantly, in cultivated ground. It may become a troublesome weed, especially in corn fields. The plant is sometimes used as food in Guatemala, but is not known to be used for this purpose elsewhere in Central America. It is also said to be used as medicine. Both samples, which undoubtedly grew as weeds, were purchased in Guatemala City, Sample (a) in February and Sample (b) in July. The leaves only of Sample (a) were chopped. The plants of Sample (b) were washed and then the leaves with some of the stem were chopped.

Nabo, plantilla de (II, *Mostaza*). This mustard is probably native to Eurasia, but is now widely distributed as a weed. The sample comprised about 50 plants about to flower. These undoubtedly grew as weeds. They were washed and dried and the leaves and tender parts of stems chopped.

Pacaya (II, *Pacaya*). Twelve immature, tender inflorescences of a palm made up the sample. The young flowers were removed and chopped.

Pito (II, *Pito*). About 50 racemes of buds and flowers were purchased. The flowers and buds were removed and mixed.

Repollo morado (I and V, *Repollo*). The sample consisted of two large, mature heads of cabbage of the purple variety. The outer leaves and the cores were removed and the remainder was chopped.

Verdolaga (I, *Verdolaga*). Purslane is a common weed. The geographical origin of the species is not known, but it may be in the area between the western Himalayas, south Russia, and Greece. There are some indications that the plant was in America in pre-Columbian times. In Central America the plant appears to be always spontaneous. It is not prized as food and is seen infrequently in markets. The sample comprised about 50 small, young, tender plants. These were washed and dried superficially and the tender parts chopped.

Yierbabuena. The bergamot mint is native to Europe. In the highlands of Central America it occurs usually as a weed, occasional to abundant, in cultivated fields or disturbed places. It is used with other foods as flavoring and possibly as a green. It is said to have medicinal properties. The sample consisted of about 50 young and tender plants taken just before flowering. These were washed and dried superficially and the tender leaves and stems chopped.

FRUIT VEGETABLES:

Aguacate (I, *Aguacate*). The samples of avocado were purchased in markets in Antigua, one in January and the other in June. Sample (a) consisted of six ripe, pear-shaped fruits with black skins, and Sample (b) of six ripe fruits with black skins and greenish-yellow flesh. For subsampling the flesh was spooned out and mixed.

Berengena (I and V, *Berengena*). Six mature eggplants with dry, white flesh were peeled and the flesh with seeds diced.

Chile pimiento (I and V, *Chile dulce;* II, *Chile chamborote*). Sixteen ripe, red, sweet peppers made up the sample. These were washed, stems and seeds removed, and the flesh chopped.

Chile Jutiapa (II, *Chile japonés*). This species of Capsicum is little known and rarely cultivated. The plant is native to Peru. It is becoming more common in Guatemala, where it is sometimes called *siete caldos.* The sample consisted of 16 fruits with thick, clear orange-yellow flesh. The fruits were washed and dried, the stems, seeds, and placentas removed, and the flesh chopped.

Güicoy (I and V, *Ayote*). The sample consisted of three mature fruits with pale to apricot-yellow flesh and very hard, yellow shells with strong ridges. The flesh was dug from one-half of each shell and mixed. Seeds were discarded.

TABLE 2

Composition of Food Samples From Guatemala

Name of food sampled			Place of origin of sample	Constituents measured and yields per 100 gm.											
Spanish	Scientific	English		Moisture	Ether extract	Crude fiber	Nitrogen	Ash	Calcium	Phosphorus	Iron	Carotene	Thiamine	Riboflavin	Niacin	Ascorbic Acid-Total
	EARTH VEGETABLES			*gm.*	*gm.*	*gm.*	*gm.*	*gm.*	*mg.*	*mg.*	*mg.*	*mg.*	*mg.*	*mg.*	*mg.*	*mg.*
Ajo	*Allium sativum* L.	Garlic	Panajachel	61.3	0.00	1.4	0.798	1.34	54.4	145.3	1.12	.002	.244	.074	.290	10.6
Camote	*Ipomoea Batatas* (L.) Lam.	Sweet potato	Antigua	70.2	0.12	1.0	0.154	.83	21.7	35.0	1.00	.064	.097	.052	1.220	32.9
Cebolla morada	*Allium Cepa* L.	Onion	Almolonga	90.8	0.04	0.5	0.164	.36	14.9	35.4	0.48	.000	.033	.019	.131	6.1
Nabo	*Brassica Rapa* L.	Turnip	Antigua	92.7	0.03	0.7	0.159	.72	31.3	22.6	0.42	.029	.038	.023	.569	27.9
Salsifí	*Tragopogon porrifolius* L.	Salsify	Guatemala	82.2	0.60	1.3	0.565	1.05	43.4	113.3	1.30	.009	.038	.045	.287	4.4
	HERBAGE VEGETABLES															
Apio	*Apium graveolens* L.	Celery	Guatemala	94.0	0.04	0.7	0.119	1.22	77.0	33.0	1.43	.048	.038	.075	.443	14.4
Apio	*Apium graveolens* L.	Celery	Bárcena	92.1	0.06	0.9	0.173	.98	55.5	34.0	0.58	.031	.040	.042	.323	15.1
Bledo	*Amaranthus hybridus* L.	.....	Antigua	87.6	0.42	1.0	0.560	2.27	295.7	75.7	33.00	5.145	.148	.325	1.103	43.6
Brusela	*Brassica oleracea* var. *gemmifera* Zenker	Brussels sprouts	Antigua	83.0	0.27	1.4	0.933	1.30	38.1	104.7	1.25	.351	.261	.167	.796	119.8
Busnay	*Spathiphyllum phryniifolium* Schott	.....	Mazatenango	82.4	1.18	1.5	1.013	1.71	402.6	135.7	1.42	.022	.037	.492	1.792	12.6
Canchón	*Brassica pekinensis* (Lour.) Rupr.	Chinese cabbage	Guatemala	96.8	0.12	0.3	0.072	.81	69.8	24.9	0.50	.009	.007	.017	.286	21.7
Coliflor	*Brassica oleracea* var. *botrytis* L.	Cauliflower	San Lucas	91.6	0.12	0.7	0.504	.91	36.7	62.8	0.84	.015	.083	.100	.823	90.7
Colinabo	*Brassica caulorapa* (D.C.) Pasq.	Kohlrabi	Guatemala	92.0	0.05	0.6	0.351	.90	26.4	49.0	0.41	.035	.066	.038	.316	78.5
Colinabo	*Brassica caulorapa* (D.C.) Pasq.	Kohlrabi	Guatemala	90.3	0.04	0.9	0.240	.81	26.8	53.3	0.40	.....	.062	.033	.356	83.3
Culantro	*Coriandrum sativum* L.	Coriander	Santiago Sacatepéquez	81.6	0.37	2.8	0.377	1.88	185.2	59.3	5.79	2.820	.135	.294	1.300	147.0
Epasote	*Chenopodium ambrosioides* L.	.....	Antigua	85.0	0.77	1.2	0.797	2.46	342.3	58.7	8.63	3.578	.166	.297	.928	99.2
Espinaca fina	*Spinacia oleracea* L.	Spinach	San Bartolomé	89.4	0.34	0.8	0.537	1.95	66.1	43.7	4.15	4.121	.160	.274	.741	58.0
Espinaca china	*Chrysanthemum segetum* L.	.....	Guatemala	93.2	0.33	0.7	0.191	1.37	124.1	49.5	3.01	1.318	.130	.102	.645	9.2
Güicoy, puntas de	*Cucurbita Pepo* L.	Growing points of squash	Near Santiago	89.4	0.36	1.0	0.601	1.44	103.5	91.5	31.26	1.122	.155	.210	1.362	50.2

Hierba San Nicolás	*Calandrinia micrantha* Schlecht.	.....	San Bartolomé	93.0	0.32	0.9	0.346	1.38	48.1	30.8	3.21	1.102	.081	.090	.367	16.7
Izote, flor de	*Yucca elephantipes* Regel	Yucca flowers	Atitlán	83.7	0.28	0.7	0.242	.76	32.5	62.3	1.55	.012	.141	.107	1.410	417.5
Loroco	*Fernaldia pandurata* (A.DC.) Woodson	.....	San Pedro Ayumpac	88.2	0.09	1.6	0.486	1.27	73.8	51.1	1.18	.169	.752	.115	2.426	13.3
Malva	*Malva parviflora* L.	.....	Antigua	77.2	0.58	1.9	1.110	3.35	627.0	122.2	40.80	12.553	.305	.634	1.768	107.7
Malva	*Malva parviflora* L.	.....	Santiago Sacatepéquez	84.9	0.73	1.9	0.809	1.89	244.2	110.2	11.03	6.328	.230	.482	1.562	119.0
Nabo, plantilla de	*Brassica campestris* L.	Field mustard	San José Pinula	88.6	0.75	0.8	0.619	1.51	280.6	48.8	3.71	5.033	.125	.274	1.244	142.0
Pacaya	*Chamaedorea Tepejilote* Liebm.	Flower of a palm	Cobán	84.5	0.62	1.0	0.670	2.00	448.0	106.3	1.05	.011	.064	.102	.718	20.7
Pito	*Erythrina Berteroana* Urban	Flower of a tree	Morán	85.0	0.22	2.1	0.510	1.16	155.8	61.4	2.48	.268	.167	.176	1.246	71.4
Repollo morado	*Brassica oleracea* var. *capitata* L.	Cabbage, purple	Antigua	90.9	0.09	0.6	0.284	.69	55.9	27.6	0.56	.016	.076	.031	.247	38.3
Verdolaga	*Portulaca oleracea* L.	Purslane	San Bartolo	92.5	0.17	0.8	0.263	1.37	77.5	37.8	4.09	.827	.021	.107	.590	31.9
Yierbabuena	*Mentha citrata* Ehrhart	.....	Antigua	89.0	0.67	0.9	0.548	1.69	175.8	49.6	5.48	5.515	.076	.238	.830	39.6
	FRUIT VEGETABLES															
Aguacate	*Persea americana* Mill.	Avocado	Antigua	79.7	12.45	1.0	0.382	1.33	6.9	56.8	0.43	.048	.070	.135	1.411	6.1
Aguacate	*Persea americana* Mill.	Avocado	Antigua	77.4	13.55	1.6	0.221	1.20	10.2	37.8	0.74	.114	.072	.091	1.222	9.3
Berengena	*Solanum Melongena* var. *esculentum* (Dunal) Nees	Eggplant	Zacapa	91.8	0.25	1.2	0.211	.65	8.1	31.1	0.65	.009	.086	.038	.751	4.1
Chile pimienta	*Capsicum annuum* var. *grossum* (L.) Sendt.	Sweet pepper, ripe	Zacapa	90.3	0.23	0.8	0.172	.56	9.0	31.2	0.53	1.190	.049	.106	.958	170.0
Chile Jutiapa	*Capsicum pubescens* Ruiz and Pavón	Hot pepper	Jutiapa	88.6	0.21	1.0	0.186	.57	7.1	19.2	0.49	.441	.061	.081	2.258	30.3
Güicoy	*Cucurbita Pepo* L.	Squash	Palencia	95.0	0.07	0.7	0.056	.66	13.3	6.1	0.38	.633	.059	.017	.419	14.0
Miltomate	*Physalis aequata* Jacq.	Ground cherry	Guatemala	90.4	0.60	1.0	0.233	.69	6.3	33.9	0.62	.061	.106	.057	2.708	4.8
Miltomate criollo	*Physalis pubescens* L.	Ground cherry	San Antonio	84.9	1.59	2.5	0.329	.94	16.7	41.0	1.25	.310	.205	.025	2.001	8.8
Pepino de fruta	*Solanum muricatum* L.	.....	Sololá	90.5	0.07	0.4	0.054	.28	3.5	16.0	0.44	.069	.054	.044	.369	62.7
Tomate verde	*Lycopersicum esculentum* Mill.	Tomato, green	Antigua	93.9	0.23	0.6	0.181	.24	5.9	20.1	0.73	.173	.074	.050	.364	11.0
	CEREALS															
Elote	*Zea Mays* L.	Green corn	Guatemala	60.1	1.17	0.8	0.760	.72	2.1	127.4	0.64	.036	.180	.091	1.459	10.5
Maíz helote	*Zea Mays* L.	Green corn	Amatitlán	63.2	0.85	0.7	0.686	.74	1.9	121.0	0.69	.076	.177	.098	1.867	9.8

TABLE 2 (*Concluded*)

Composition of Food Samples From Guatemala

Name of food sampled			Place of origin of sample	Constituents measured and yields per 100 gm.												
Spanish	Scientific	English		Moisture	Ether extract	Crude fiber	Nitrogen	Ash	Calcium	Phosphorus	Iron	Carotene	Thiamine	Riboflavin	Niacin	Ascorbic Acid-Total
				gm.	*gm.*	*gm.*	*gm.*	*gm.*	*mg.*	*mg.*	*mg.*	*mg.*	*mg.*	*mg.*	*mg.*	*mg.*
	LEGUMES															
Alverja	*Pisum sativum* L.	Pea	Santa María del Volcán de Agua	77.7	0.23	1.7	1.000	.67	21.9	93.6	1.99	.180	.440	.159	2.100	43.6
Ejote	*Phaseolus vulgaris* L.	Snap bean, green	Santiago Sacatepéquez	91.3	0.16	1.0	0.299	.61	55.3	37.5	0.78	.356	.073	.108	.477	13.1
Haba	*Vicia Faba* L.	Horse bean	Santiago Sacatepéquez	78.8	0.14	0.2	1.353	.74	31.5	91.1	2.33	.114	.173	.187	1.248	36.2
	FRUITS															
	1. Citrus															
Cidra	*Citrus medica* L.	Citron	Guatemala	87.1	0.04	1.1	0.081	.41	36.5	16.0	0.55	.009	.052	.029	.125	36.8
Lima	*Citrus aurantifolia* (Christm.) Swingle	Sweet lime	Rabinal	90.8	0.08	0.5	0.103	.40	30.5	18.9	0.33	.040	.068	.018	.241	45.1
Mandarina	*Citrus reticulata* Blanco	Tangerine	Near San José	82.6	0.30	0.7	0.154	.54	46.8	23.4	0.20	.373	.113	.037	.231	54.4
Mandarina	*Citrus reticulata* Blanco	Tangerine	Near Palin	83.9	0.12	0.4	0.168	.33	36.0	19.0	0.26	.013	.099	.041	.281	47.2
Naranja agria	*Citrus Aurantium* L.	Sour orange	Antigua	77.8	0.07	2.2	0.154	.69	81.9	20.4	0.22	.071	.048	.040	.400	103.5
	2. Banana															
Guineo morado blanco	*Musa paradisiaca* var. *sapientum* L.	Red banana	Escuintla	71.0	0.18	0.3	0.237	.89	10.2	17.7	0.33	.234	.034	.030	.670	10.3
	3. Other															
Anona	*Annona squamosa* L.	.....	San Juan Sacatepéquez	71.1	0.06	1.1	0.191	.55	19.4	23.6	0.28	.007	.109	.113	.654	39.8
Azerola	*Malpighia glabra* L.	.....	Amatitlán	81.9	0.09	1.2	0.266	.77	34.6	33.1	1.01	.042	.024	.038	.526	15.5
Caimito	*Chrysophyllum Cainito* L.	Star apple	Escuintla	82.4	2.98	0.8	0.171	.35	15.7	16.3	0.34	.011	.018	.013	1.340	6.3
Chico	*Achras Zapota* L.	Níspero	Zacapa	73.7	0.85	1.6	0.056	.40	19.8	6.0	0.33	.016	.002	.012	.149	11.3
Chico	*Achras Zapota* L.	Níspero	San Agustín	76.9	1.79	1.1	0.052	.48	22.3	10.9	0.59	.020	.002	.023	.202	35.2
Ciruela	*Prunus domestica* L.	Plum	San Lucas	85.7	0.15	0.3	0.106	.31	6.9	13.8	0.60	.004	.019	.023	.312	7.6

Coco	*Cocos nucifera* L.	Coconut meat	San José	52.2	29.85	3.5	0.631	1.05	8.9	90.0	1.76	.000	.058	.017	.542	4.2
Coco, leche de	*Cocos nucifera* L.	Coconut milk	San José	95.8	<0.01	<0.1	0.039	.57	22.8	12.4	0.26	.003	.001	.004	.075	1.9
Durazno	*Prunus persica* (L.) Sieb. and Zucc.	Peach	Chichicastenango	85.5	0.87	0.5	0.126	.50	4.2	21.7	0.39	.009	.027	.028	.340	12.9
Fresa	*Fragaria vesca* L.	Strawberry	Mariscal	88.4	0.12	1.3	0.145	.38	26.0	46.7	0.70	.014	.034	.033	.318	74.3
Guanábana	*Annona muricata* L.	Soursop	Zacapa	80.6	0.12	1.1	0.183	.63	14.9	25.7	0.24	.004	.116	.028	.939	21.3
Guayaba	*Psidium Guajava* L.	Guava	Antigua	78.9	0.39	5.3	0.118	.43	9.1	17.8	0.30	.008	.046	.040	1.068	279.0
Injerto	*Calocarpum viride* Pitt.	Sapote, green	Ciudad Vieja	68.1	0.24	1.2	0.192	.69	18.6	22.1	0.57	.069	.009	.027	1.189	62.3
Mamey	*Mammea americana* L.	Mamey	Escuintla	86.5	0.22	0.9	0.088	.26	11.2	11.2	0.28	.125	.025	.068	.738	21.0
Mango verde	*Mangifera indica* L.	Mango, green	San Agustín de Zacapa	85.9	0.07	1.0	0.070	.31	21.0	7.3	0.25	.067	.023	.023	.165	143.3
Manzanilla	*Crataegus pubescens* (HBK.) Steud.	.....	Santa María Jesús	76.0	0.43	2.0	0.101	.78	91.1	18.4	2.56	.539	.025	.041	.312	90.2
Marañón	*Anacardium occidentale* L.	"Cashew apple"	Zacapa	84.4	0.50	0.7	0.162	.34	3.1	21.4	0.33	.742	.015	.016	.539	347.8
Melocotón	*Sicania odorifera* (Vell.) Naud	.....	San José	85.1	0.02	1.1	0.145	.70	21.1	24.5	0.33	.011	.058	.035	.767	13.9
Melón	*Cucumis Melo* var. *reticulata* Naud.	Melon	Cerritos	93.3	0.19	0.4	0.052	.42	9.7	13.7	0.24	.771	.026	.020	.700	32.5
Membrillo	*Cydonia oblonga* var. *maliformis* (Mill.) Schneid.	Quince	San Juan Sacatepéquez	86.8	0.05	1.5	0.042	.38	4.7	19.1	0.65	.004	.029	.018	.176	23.5
Papaya	*Carica Papaya* L.	Papaya	Escuintla	89.3	0.10	0.6	0.110	.46	18.3	11.8	0.25	.045	.025	.029	.238	47.5
Papaya	*Carica Papaya* L.	Papaya	Escuintla	88.6	0.06	0.7	0.097	.57	17.5	15.5	0.42	.241	.030	.038	.399	60.5
Pera larga	*Pyrus communis* L.	Pear	San Lucas	85.5	0.07	0.9	0.027	.28	6.9	6.9	0.61	.001	.018	.014	.262	4.9
Pitahaya	*Hylocereus undatus* (Haworth) Britt. and Rose	.....	Atitlán	82.5	0.21	0.7	0.159	.54	8.8	30.2	0.55	.012	.043	.045	.297	9.0
Sandia	*Citrullus vulgaris* Schrad.	Watermelon	Zacapa	93.6	0.16	0.1	0.075	.19	3.7	5.6	0.38	.029	.015	.019	.160	7.2
Sapote	*Calocarpum mammosum* (L.) Pierre	Sapote	Escuintla	73.1	0.56	1.5	0.308	.94	29.5	24.8	0.75	.045	.009	.012	2.580	8.8
Zapote	*Calocarpum mammosum* (L.) Pierre	Sapote	El Rancho	61.3	0.82	2.0	0.188	1.05	42.3	24.4	0.52	.065	.025	.009	1.675	14.3
	MISCELLANEOUS															
Hongo de San Juan	*Boletus sp.*	A gill fungus	San Juan Sacatepéquez	93.6	0.04	1.0	0.322	.81	3.1	44.1	3.19	.005	.014	.338	1.053	1.3

Miltomate [II, *Tomatillo* (b)]. About 100 ripe ground-cherry fruits were purchased in Antigua. After removing the husks, the fruits were washed and dried, then chopped.

Miltomate criollo (II, *Miltomate*). About 600 ripe fruits were purchased in a market in Antigua. These were from wild plants. The husks were removed and the whole fruits mixed for subsampling.

Pepino de fruta [II, *Pepino* (c)]. The sample consisted of 12 ripe fruits with pale yellow-green, very moist flesh. These probably came from wild plants. They were peeled and the flesh cut into pieces and mixed.

Tomate verde (I and V, *Tomate*). Fifteen hard, green fruits made up the sample. These were washed and dried before subsampling.

CEREALS:

Elote and *maíz helote* (I, *Jilote*). The sample of *maíz helote* consisted of 12 ears of yellow-kerneled corn at the soft-dough stage. The sample of *elote* was made up of six large ears of native yellow-dent at the dough stage with red cobs. For subsampling the kernels were cut from the cobs and mixed.

LEGUMES:

Alverja (III, *Alverja*). Several hundred pods of mature, fresh peas were shelled and mixed.

Ejote (I, *Habichuela*). About 200 fresh, green, mature pods were washed and dried, trimmed, and chopped.

Haba (III, *Haba*). About 200 mature green pods of the horse bean made up the sample. The beans were shelled, the integuments removed, and the cotyledons mixed for subsampling.

FRUITS

CITRUS:

Cidra. The citron has been in cultivation for at least 4,000 years. The plant may have originated in India, although wild plants are not known with certainty in any locality. The plant is not common in Central America and was seen for sale only once. It is used for citron peel, a preserve made with sugar, or to make a syrup. The sample comprised five ripe fruits. A longitudinal quarter was taken from each fruit and the skin and centers removed. The remaining thick, white portion of peel was diced.

Lima (III, *Lima*). The sample comprised 14 large umbonate fruits of the sweet lime. The peels were yellow-green and the flesh very pale greenish-yellow with loose white seeds. The fruits were peeled, the seeds removed, and a section from each taken for each sample.

Mandarina (I, *Mandarina*). Two samples of tangerines were purchased in Guatemala City, one in February and the other in July. Sample (a) was made up of 30 small, fine-flavored, ripe fruits with orange-red peels and deep orange flesh. Sample (b) comprised 12 good-quality fruits not quite ripe but with the peels beginning to show yellow. For subsampling Sample (a) the fruits were peeled, seeds removed, and the remainder slurried. Fruits of Sample (b) were peeled and the seeds removed. An equal number of sections were then taken from each fruit for each subsample.

Naranja agria (IV, *Naranja agria*). The sample consisted of 14 mature, sour oranges. These had orange-colored skins and were very acid. The superficial layer of peel and the oil glands were removed. A longitudinal wedge of the pulp (no seeds) and remaining peel was taken from each fruit for the subsamples.

BANANA:

Guineo morado blanco (I and V, *Banano*). The 11 ripe bananas that made up the sample represented the yellow-skinned form of a red-skinned variety. They are used raw or for cooking. The fruits were peeled and the pulp mashed together.

OTHER:

Anona (I, *Anona blanca*). The sugar apple is undoubtedly of American origin but was distributed over much of the tropical area of the world soon after the discovery of America. It is considered to be one of the best of the Annonas and its excellent fruits are highly prized. Four ripe fruits of about 700 gm. made up the sample. The pulp was spooned out of the shells, freed of seeds, and mixed.

Azerola (III, *Azerola*). About 200 ripe, red-skinned fruits of the Barbados cherry were purchased in Guatemala City. The flesh of these fruits was acid. They were washed and dried, the stems and seeds removed, and the flesh and skins cut up and mixed.

Caimito (III, *Caimito*). The sample consisted of 18 medium-sized, ripe fruits of the star apple. These were cut in half, the seeds removed, and the flesh spooned out and mixed.

Chico (I and V, *Níspero*). Sample (a), purchased in January, comprised 18 medium-sized ripe fruits and Sample (b), purchased in July, five ripe fruits with brownish-pink, moist flesh. The fruits were opened, the seeds removed, and the flesh spooned out and mixed.

Ciruela (III, *Ciruela*). Fifteen ripe plums with yellowish or pink flesh were washed and a longitudinal section was cut from each for each subsample.

Coco (I, *Coco*). The coconut palm is probably native to the Malayan region but may have reached the west coast of tropical America in pre-Columbian times. It was certainly introduced on the Pacific shores of the Americas after the time of discovery. The sample consisted of four ripe fruits still in the husk. The milk was extracted and mixed for the sample of *leche de coco* and then the flesh was removed, diced, and slurried.

Coco, leche de. See *Coco.*

Durazno (III, *Durazno*). The 12 peaches purchased were nearly ripe and of good quality for Central America. They were peeled and the flesh cut from the seeds and mixed.

Fresa (VI, *Fresa*). The sample consisted of about 200 fresh, ripe strawberries. They were washed, hulled, and mixed by slurrying.

Guanábana (VI, *Guanábana*). The sample comprised four medium-sized ripe soursop fruits. The pulp was spooned out of the shells, freed of seeds, and mixed.

Guayaba (III, *Guayaba*). The 20 guavas purchased had yellowish peels, whitish-yellow flesh with a pink tinge, and were of good quality.

They were washed and dried, the hard ends were cut off, and longitudinal wedges including skin, flesh, and seeds taken for the subsamples.

Higo (III, *Higo*). Thirty-six figs made up the sample. These were green with some purple beginning to show. The flesh was white and dry. They were washed and dried, the stems removed, and the remainder diced.

Injerto (III, *Injerto*). The sample comprised six ripe sapote fruits with soft, moist, sweet, flesh-colored flesh of good flavor. The flesh was spooned out of the shells, freed of seeds, and mixed.

Mamey (III, *Mamey*). The five rather large, ripe fruits of the sample of mamey had firm, apricot-colored flesh. They were peeled and the flesh cut from the seeds and diced.

Mango verde. The mango is perhaps the fruit tree which has been most widely cultivated in tropical and subtropical lands, and the fruit is undoubtedly more important than any other in the dietary of tropical peoples. The species is apparently native to southern Asia and the Malayan region, but was so much appreciated and even venerated in ancient times that it was undoubtedly widely spread by human agency. There is evidence that it has been in cultivation for more than 6,000 years. The mango is believed to have been brought to the Americas by the Portuguese and to have been established in Brazil about the beginning of the 18th century. From there it was brought to the West Indies and then into Central America. The mango is one of the few tropical cultivated food plants that has been improved under cultivation. There are now many excellent grafted varieties. The sample consisted of 11 green fruits with hard flesh. These were washed and the skin and flesh cut from the seed and mixed.

Manzanilla (III, *Manzanilla*). About 100 ripe, yellow fruits made up the sample. These had rather dry flesh. They were washed and dried and the flesh and skin cut away from the core and mixed.

Marañón (IV, *Marañón*). The sample consisted of 24 ripe cashew apples with moist, rather acid, apricot-yellow colored flesh. These fruits probably came from wild plants. They were washed and dried, the "nut" removed, and the fruits or fleshy pedicels diced and mixed.

Melocotón (V, *Cojombro*). The sample comprised three ripe, sausage-shaped fruits of about 3,500 gm. The skins were deep purple and the flesh yellow, firm, and fragrant. The centers were full of soft pulp and seeds. For subsampling, a longitudinal quarter-section was taken from each fruit, then the outer peel and the seeds and wet inner pulp were removed, and the rind diced.

Melón (IV, *Melón*). Two ripe melons were purchased. The flesh was orange-yellow toward the center and greenish toward the skin. The orange-yellow portion of the flesh from one-half of each fruit was removed and diced.

Membrillo (I and III, *Membrillo*). Quinces are native to western Asia and have been in cultivation since ancient times. Little change has taken place in the fruit in cultivation. The sample consisted of 12 ripe or nearly ripe fruits with firm, pale yellow-green flesh. These were peeled, cored, and the flesh diced.

Papaya (III, *Papaya*). Sample (a), purchased in January, consisted of three fruits with flesh either green or beginning to turn yellow; Sample (b), obtained in June, of two ripe fruits with moist, sweet, yellow-red flesh. Subsamples of both samples were prepared by taking longitudinal quarter-sections from each fruit, removing the peel and seeds, and dicing the flesh.

Pera larga (III, *Pera larga*). The eight fairly large fruits used had white flesh and large stone cells. They were peeled, cored, and the flesh diced.

Pitahaya (III, *Pitahaya*). Eight ripe, good-quality fruits made up the sample. These had moist, slightly sweet, bright purple flesh with small black seeds. The flesh with seeds was spooned out of the shells and mixed.

Sandía (V, *Sandía*). Two relatively small, ripe watermelons were purchased. The flesh of each was red but not very firm. The flesh was taken from one-half of each fruit, freed of seeds, and diced.

Sapote and *Zapote* (I, *Zapote*). Sample (a) of sapote comprised six ripe, medium-sized fruits and Sample (b) six tree-ripened fruits. These were subsampled by spooning the flesh from the shells, removing the seed, and mixing. Orange-colored flesh only was used from the fruits of Sample (b).

Zapote. See *Sapote*.

MISCELLANEOUS:

Hongo de San Juan. This is a gill fungus used in much the same manner as mushrooms. About 30 plants were obtained in the Guatemala market. These were just less than mature. The flesh was almost white, both in the cap and stipe, and was fairly moist. For subsampling, the epidermis was removed from the stipe, cap, and annulus. A small portion of the flesh of each plant was then taken for each subsample.

RESULTS AND DISCUSSION

Values obtained for the 13 constituents measured in the 79 samples analyzed are shown in Table 2. As in previous reports, the foods have been grouped under the main headings of Earth Vegetables, Herbage Vegetables, Fruit Vegetables, Cereals, Legumes, and Fruits, with one under Miscellaneous. All samples were of fresh foods.

Ten of the foods listed in this paper have not been reported upon in previous papers of this series. These included *busnay, culantro, epasote, espinaca china, hierba San Nicolás, malva,* and *yierbabuena* under Herbage Vegetables; *cidra* and *melón* under Fruits; and *hongo de San Juan,* classified as Miscellaneous. Some of these were high in content of several nutrients. *Busnay* showed high values for calcium (402.6 mg.), riboflavin (0.492 mg.), and niacin (1.792 mg.); *culantro* for calcium (185.2 mg.), iron (5.79 mg.), carotene (2.820 mg.), riboflavin (0.294 mg.), and ascorbic acid (147.0 mg.); *epasote* for calcium (342.3 mg.), iron (8.63 mg.), carotene (3.578 mg.), riboflavin (0.297 mg.), and ascorbic acid (99.2 mg.); *espinaca china* for calcium (124.1 mg.) and iron (3.01 mg.); *hierba San Nicolás* for iron (3.21 mg.); *malva* for calcium (627.0 and 244.2

mg.), iron (40.80 and 11.03 mg.), carotene (12.553 and 6.328 mg.), thiamine (0.305 and 0.230 mg.), niacin (1.768 and 1.562 mg.), and ascorbic acid (107.7 and 119.0 mg.); and *yierbabuena* for calcium (175.8 mg.), iron (5.48 mg.), carotene (5.515 mg.), and riboflavin (0.238 mg.). *Malva* is outstanding among these, and as stated under the description of this plant, it is sometimes used as food in Guatemala and probably could be used elsewhere and even more extensively in Guatemala with considerable benefit. The fruits *cidra* and *melón* are not remarkable in respect to nutrient content, although both contained appreciable amounts of ascorbic acid (36.8 and 32.5 mg., respectively). The fungus, *hongo de San Juan*, is mediocre in nutrient content, although the values for iron (3.19 mg.), riboflavin (0.338 mg.), and niacin (1.053 mg.) are of interest, considering the high water content of the material.

A number of other foods show high values for one or more constituents. All of these have been listed in previous reports, as indicated by the series number of the paper after the name of the food in the following discussion.

Among the herbage vegetables *bledo* (II) gave high values for calcium (295.7 mg.), iron (33.00 mg.), carotene (5.145 mg.), and riboflavin (0.325 mg.); *espinaca fina* (VI) for iron (4.15 mg.), carotene (4.121 mg.), and riboflavin (0.274 mg.); *puntas de güicoy* (II) for calcium (103.5 mg.), iron (31.26 mg.), and riboflavin (0.210 mg.); *flor de Izote* (II, IV, and VI) for ascorbic acid (417.5 mg.); *loroco* (IV) for thiamine (0.752 mg.) and niacin (2.426 mg.); *plantilla de nabo* (II) for calcium (280.6 mg.), iron (3.71 mg.), carotene (5.033 mg.), riboflavin (0.274 mg.), and ascorbic acid (142.0 mg.); *pacaya* (II) for calcium (448.0 mg.); *pito* (II and IV) for calcium (155.8 mg.) and iron (2.48 mg.), with moderately high values for thiamine (0.167 mg.) and riboflavin (0.176 mg.). Three of the fruit vegetables and one of the fruits gave high values for niacin: *chile Jutiapa* (II) (2.258 mg.), *miltomate* (II) (2.708 mg.), *miltomate criollo* (II) (2.001 mg.); and *sapote* (I, II, IV, V, and VI) (2.580 mg.). Two fruits gave remarkably high values for ascorbic acid: *guayaba* (II, IV, and V) (279.0 mg.) and *marañón* (IV and VI) (347.8 mg.).

SUMMARY

Data are shown for the content of moisture, ether extract, crude fiber, nitrogen, ash, calcium, phosphorus, iron, carotene, thiamine, riboflavin, niacin, and ascorbic acid in 79 samples of edible plants obtained in Guatemala. All except one of these were purchased in markets.

Ten of the foods listed have not been included in previous reports of this series. Seven of these were among the foods classified as Herbage Vegetables and all seven show high values for one or more nutrients: busnay for calcium, riboflavin, and niacin; *culantro* and *epasote* for calcium, iron, carotene, riboflavin, and ascorbic acid; *espinaca china* for calcium and iron; *hierba San Nicolás* for iron; *malva* for calcium, iron, carotene, thiamine, riboflavin, niacin, and ascorbic acid; and *yierbabuena* for calcium, iron, carotene, and riboflavin.

Several other foods with high values have been included in previous lists: *bledo, espinaca fina, puntas de güicoy, flor de Izote, loroco, plantilla*

de nabo, pacaya, pito, chile Jutiapa, miltomate, miltomate criollo, guayaba, marañón, and *sapote.*

Attention is called to the fact that several fruits had high values for niacin.

The values for the iron, riboflavin, and niacin content of the fungus, *hongo de San Juan,* are of interest.

ACKNOWLEDGMENT

This investigation was supported by a grant from the United Fruit Company to the Central American Nutrition Foundation, and was conducted jointly by the Massachusetts Institute of Technology and Escuela Agrícola Panamericana, Dr. Wilson Popenoe, Director.

REFERENCES

CRAVIOTO, B. R., LOCKHART, E. E., ANDERSON, R. K., DE P. MIRANDO, F., AND HARRIS, R. S., 1945. Composition of typical Mexican foods. J. Nutrition **29**, 317-329.

MUNSELL, H. E., WILLIAMS, L. O., GUILD, L. P., TROESCHER, C. B., NIGHTINGALE, G., AND HARRIS, R. S., 1949. Composition of food plants of Central America I. Honduras. Food Research **14**, 144-164.

———, ———, ———, ———, ———, AND ———, 1950a. Composition of food plants of Central America. II. Guatemala. Food Research **15**, 16-33.

———, ———, ———, ———, ———, AND ———, 1950b. Composition of food plants of Central America. III. Guatemala. Food Research **15**, 34-52.

———, ———, ———, ———, ———, KELLEY, L. T., AND HARRIS, R. S., 1950c. Composition of food plants of Central America. IV. El Salvador. Food Research **15**, 263-296.

———, ———, ———, ———, AND HARRIS, R. S., 1950d. Composition of food plants of Central America. V. Nicaragua. Food Research **15**, 355-365.

———, ———, ———, KELLEY, L. T., MCNALLY, A. M., AND HARRIS, R. S., 1950e. Composition of food plants of Central America. VI. Costa Rica. Food Research **15**, 379-404.

———, ———, ———, ———, AND HARRIS, R. S., 1950f. Composition of food plants of Central America. VII. Honduras. Food Research **15**, 421-438.

SPORES OF *CLOSTRIDIUM BOTULINUM* IN GEORGIA SOIL

ROY E. MORSE,[1] JOHN J. POWERS, AND CARL J. WILLIAMS
Department of Food Technology, University of Georgia, Athens, Georgia

[Received for publication, May 21, 1950]

The prevalence of the spores of *Clostridium botulinum* is a subject which has been the topic of frequent discussions since the classical studies of Meyer and Dubovsky (1922a). The importance to the canning industry of this organism is too well known to be further discussed. Ever since Burke (1919) established that the habitat of this organism is the soil, examinations have turned in this direction to determine the potential menace facing the canning industry of the area under study. This study was undertaken to establish the prevalence of such spores in Georgia, an area where pimientos, usually a low-acid food, are frequently canned by boiling-water-bath process.

Typical of the many studies seeking *Cl. botulinum* in the soil are those of Burke (1919), Meyer and Dubovsky (1922a and b), Tanner and Dack (1922), and Nelson (1948). Virtually identical techniques were employed in all the above studies.

Burke (1919) employed a meat infusion broth, but in later studies shifted to beef heart peptic digest medium, which he reported to be a superior medium. Hill and Lewis (1947) reported a skim milk and a corn steep liquor-casein medium which they found to be satisfactory for the culture of putrefactive anaerobes. Perry, Townsend, Anderson, and Berry (1948) adapted the latter medium to a study of *Cl. botulinum* in frozen foods and reported that the medium performed satisfactorily. Liggett and Koffler (1948) reviewed the literature on corn steep liquor and gave details of its composition.

The test animal to be used in the study of this organism has been the subject of considerable controversy. Lamanna and Glassman (1947) compared guinea pigs and mice and found guinea pigs to be three times as sensitive as mice to the toxin studied. However, Stevenson, Nelson, and Reed (1947) found the guinea pig to be six to eight thousand times as sensitive to Type B toxin as the mouse. Tanner (1933) considered the mouse to be a poor test animal because it was more refractory than commonly believed. Smith and Martin (1948) considered the mouse, guinea pig, and monkey to be satisfactory animals for studies with *Cl. botulinum* toxin. Burke (1919), Meyer and Dubovsky (1922a), and Parry (1945) all used the guinea pig as a test animal. However, Perry *et al.* (1948) and Lamanna and Glassman (1947) used mice and considered them satisfactory test animals.

[1] Present address: Research Food Technologist, Monsanto Chemical Company, Anniston, Alabama.

METHODS

A study was made to determine the relative toxin-producing effectiveness of beef heart peptic digest broth (BHPD) prepared according to Lepper, Fisher, Warren, Sale, Ross, Reindollar, and Marian (1945) and corn steep liquor-casein (CSLC) medium prepared according to Perry *et al.* (1948). The organism used was a known culture of *Cl. botulinum* (Strain A 62) taken from the collection of Dr. K. F. Meyer and kindly furnished for these studies by Mr. C. W. Bohrer of the National Canners Association Laboratories. The mouse was used as the test animal.

Mice and guinea pigs were compared as test animals, using CSLC. After separation of the toxin from the culture, the mice were injected intravenously with 0.09 ml. in the lateral tail vein. Prior to inoculation the site was moistened with alcohol, to serve as an irritant and bring the vein into prominence. The animal was held in a specially designed animal board (shown Fig. 1). The mouse, suspended by the tail, is lowered into the corrugated paper cone. Its tail is then threaded through the hole in the mouse board and the corrugated cone fitted tightly into the wooden form. The mouse is thus immobilized and the worker's two hands are freed to conduct the inoculation. A control mouse was injected with a portion of the same material which had been detoxified by exposure to a boiling-water bath for 10 minutes.

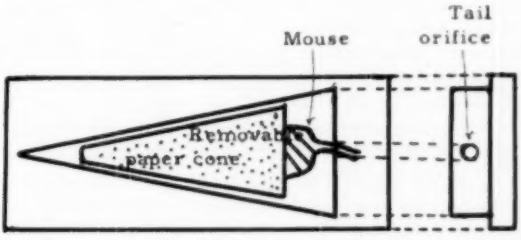


FIG. 1. Mouse board for lateral tail vein inoculation (after Mirone).

The guinea pigs were injected subcutaneously with 0.5 ml. between the hind legs. For inoculation the animal was held on its back. The same toxin culture was used for both mice and guinea pigs.

The minimum lethal dose for mice was determined by diluting the toxin with physiological saline as follows: one to 100, one to 10,000, one to 1,000,000, and one to 100,000,000. Detoxified controls were also run. Observation was for seven days.

Attempts were made to recover the organism from sterile soil, and soil *in situ*. Ten ml. of detoxified culture were poured onto 100 gm. of sterile soil and thoroughly mixed. In the *in situ* study the detoxified culture was poured onto the ground and mixed to a depth of about eight inches, and soil samples taken 36 hours later.

The soil enrichment method used was adapted from Waksman (1927). A 30-gm. soil sample was mixed with 100 ml. of sterile physiological saline. This mixture was shaken 100 times at an angle of 45° and swirled. Ten

ml. of the supernatant liquid were pipetted into each of two test tubes and exposed to a boiling-water bath for 10 minutes to destroy vegetative cells. After shock-cooling in ice water, two ml. were pipetted into 18 ml. of sterile CSLC, mixed, and incubated 10 days at 34°C.(93°F.). Contents of tubes showing growth were transferred into sterile tubes and centrifuged at 1,500 r.p.m. for 15 minutes. The supernatant liquid was used for inoculation as described above.

Another study was made to determine the minimal spore concentration recoverable from the soil, using CSLC and mice. Spore counts were made on a culture according to Miller, Garrett, and Prickett (1939), who used pork agar in Prickett tubes. Spore concentrations were 100, 1,000, 10,000, 100,000, and 1,000,000 spores per gm. of sterile soil. Previous to admixture with the soil the culture was placed in a boiling-water bath for 10 minutes to inactivate vegetative cells. The treated soil was then run through the routine test.

Finally, samples of soil were collected from various parts of Georgia and from various soil types and locations, including virgin forest, orchards, and fields under cultivation. During the summer of 1948, 147 samples were collected, and five samples during the fall of 1949.

TABLE 1

Minimum Lethal Dose of Toxin

Toxin dilution	No. of animals	No. of deaths	Time for death
			hr.
Undiluted	4	4	0.75 to 9
Control	3	0	....
One to 100	2	2	10
Control	2	0	....
One to 10,000	2	2	12
Control	2	0	....
One to 1,000,000	2	2	9
Control	2	0	....
One to 100,000,000	2	0	....
Control	2	0	....

RESULTS

Both CSLC and BHPD were found to support growth and toxin production of *Clostridium botulinum*. Toxin production was found to be slightly more rapid on CSLC. The serious disadvantage of BHPD is the time and effort involved in its preparation; seven days are required for preparation, while only about two hours are needed for CSLC medium.

All animals tested in the comparison between guinea pigs and mice died, and the controls were unaffected. The mice usually died one to four hours earlier than the guinea pigs.

Results of the study to determine minimal lethal dose for mice are shown (Table 1). The minimal dose was found to be between dilutions of one to 1,000,000 and one to 100,000,000.

In the attempt to recover known cultures from sterile soil and soil *in situ*, the sample mixed with sterile soil proved positive, while that in soil *in situ* proved negative.

In the study to determine the minimal number of organisms required to be present in soil before a positive response was elicited to the CSLC-mouse test, it was found that 100,000 spores per gm. of soil were required. Results are shown (Table 2).

TABLE 2

Number of Spores Required for Recovery From Soil

No. of spores in soil	No. of animals	No. of deaths
per gm.		
100	2	0
Control	1	0
1,000	2	0
Control	1	0
10,000	2	0
Control	1	0
100,000	2	2
Control	1	0
1,000,000	2	2
Control	1	0

Of the 152 soil samples analyzed, only one positive was found. Upon testing with Antitoxin AB it was found to belong to this group.

DISCUSSION

The method of testing soil samples for the presence of spores of *Cl. botulinum*, using CSLC medium and mice, appears to be a satisfactory one. The medium can apparently be applied to mice or guinea pigs with equally satisfactory results. Previous workers have shown that BHPD is better adapted to guinea pigs than to mice. The combination of CSLC with mice seems to be slightly better than this medium with guinea pigs.

Possible explanations for the failure of the method to recover known cultures from soil *in situ* are selection of an incorrect environment, which might include unfavorable pH, deficiency of symbiotic organisms, and an incorrect time interval to set up anaerobic conditions. At any rate, it seems to be difficult to recover a known culture which has been maintained under laboratory conditions, after mixing it with soil under natural conditions.

Of the 152 samples of soil analyzed only one positive was found; this compares with the study of Meyer and Dubovsky (1922b), who found none out of seven examined.

SUMMARY

A method of analyzing soil samples for the presence of spores of *Cl. botulinum*, using corn steep liquor-casein medium with the mouse as the test animal, is presented.

Using this method it was found that 100,000 spores per gm. of soil were required for positive results.

The toxin produced using the above method could be diluted one to 1,000,000 and still give positive results.

A positive test was achieved from inoculated sterile soil, but not from soil *in situ*.

Of 152 soil samples collected in Georgia, one positive sample was recovered which proved to belong to Group AB of *Cl. botulinum*.

ACKNOWLEDGMENTS

Grateful acknowledgment is made to Dr. Leonore Mirone, Associate Professor of Nutrition Research, for advice on the care and handling of laboratory animals, and to Dr. H. E. Calkins, Assistant Professor of Bacteriology, for criticism and guidance in the course of these experiments.

REFERENCES

BURKE, G. S., 1919. The occurrence of *Bacillus botulinus* in nature. J. Bact. **4**, 541-553.

HILL, E. V., AND LEWIS, K. H., 1947. Practical media and control measures for producing highly toxic cultures of *Clostridium botulinum*, Type A. J. Bact. **53**, 213-230.

LAMANNA, C., AND GLASSMAN, H. N., 1947. The isolation of Type B botulinum toxin. J. Bact. **54**, 575-584.

LEPPER, H. A., FISHER, H. J., WARREN, L. E., SALE, J. W., ROSS, W., REINDOLLAR, W. F., AND MARIAN, L. O., 1945. Methods of Analysis of the Association of Official Agricultural Chemists. Sixth ed., pp. 757-758. Assoc. Official Agr. Chem., Washington, D. C.

LIGGETT, R. W., AND KOFFLER, H., 1948. Corn steep liquor in microbiology. Bact. Revs. **12**, 297-311.

MEYER, K. F., AND DUBOVSKY, B., 1922a. The distribution of spores of *Bacillus botulinus* in California. J. Infectious Diseases **31**, 541-555.

———, AND ———, 1922b. The distribution of the spores of *Bacillus botulinus* in the United States. J. Infectious Diseases **31**, 559-594.

MILLER, N. J., GARRETT, O. W., AND PRICKETT, P. S., 1939. Anaerobic technique. A modified deep agar shake. Food Research **4**, 447-451.

NELSON, C. I., 1948. Study on botulinum toxin. Proc. North Dakota Acad. Sci. Vol. 1, 31-37.

PARRY, E. W., 1945. Prevalence of *Clostridium botulinum* in soils of Central New York State. Food Research **11**, 203-209.

PERRY, H., TOWNSEND, T. C., ANDERSON, A. A., AND BERRY, J. A., 1948. Studies on *Clostridium botulinum* in frozen pack vegetables. Food Tech. **2**, 180-190.

SMITH, D. T., AND MARTIN, D. S., 1948. Zinsser's Textbook of Bacteriology. Ninth ed., pp. 280-285. Appleton-Century-Crafts, Inc., New York, New York.

STEVENSON, J. W., NELSON, V. A., AND REED, G. B., 1947. Preparation of *Clostridium parabotulinum* toxins. Can. J. Research, E. **25**, 14-24.

TANNER, F. W., 1933. Food-borne Infections and Intoxications, pp. 330-419. The Garrard Press, Champaign, Illinois.

———, AND DACK, G. M., 1922. *Clostridium botulinum*. J. Infectious Diseases **31**, 92-100.

WAKSMAN, S. A., 1927. Principles of Soil Microbiology. Baillière, Tindall, and Cox, London.

EFFECT OF MONOSODIUM GLUTAMATE ON TASTE OF PURE SUCROSE AND SODIUM CHLORIDE

ERNEST E. LOCKHART AND JEAN MURRAY GAINER
Department of Food Technology, Massachusetts Institute of Technology, Cambridge, Massachusetts

[Received for publication, May 21, 1950]

Monosodium glutamate is today widely used in meat and fish products, soups, seafoods, vegetables, and cereals to enhance natural flavor elements and contribute satiety value. This white, crystalline substance apparently possesses no odor when pure and only a mildly sweet-salty taste, but contributes to foods to which it is added certain elements of taste feeling that make it unique as a flavoring agent.

Although the literature abounds with descriptions of the manufacture, properties, and utilization of glutamate in foods, few reports discuss its effect on primary taste sensation.

Cairncross and Sjöström (1948) found that in tests with aqueous solutions "glutamate appears to be more salty than salt at the 0.1 to 0.2 per cent level (subthreshold level of salt) and at threshold levels glutamate adds some saltiness to salt solutions. Above threshold, saltiness of salt solutions is not greatly increased by adding MSG." The authors do not state whether the threshold values referred to are literature-derived standards or whether they were determined for the particular judges employed in the tests.

Galvin (1948), having noted that salt plays an important role in the glutamate effect, made a series of observations on aqueous solutions in which the glutamate concentration was varied between 0.05 and 1.0 per cent (0.003 and 0.058 M), while the salt concentration was varied from 0.25 to 1.0 per cent (0.042 to 0.168 M). He reported that at the lowest salt level, glutamate concentrations from 0.05 to 0.25 per cent (0.003 to 0.015 M) had noticeable normal glutamate tastes, whereas those of 0.5 and 1.0 per cent (0.03 and 0.06 M) had a distinct and very prominent sweetness, which overshadowed the normal glutamate character. In 0.5 per cent (0.084 M) salt solution, the normal glutamate effect was present throughout all concentrations of glutamate observed, except the highest (1.0 per cent, 0.06 M), which showed additional sweetness. At the highest salt level, the lower concentrations of glutamate had a normal glutamate taste and the saltiness of the solution was materially diminished, but when 1.0 per cent (0.06 M) glutamate was used no reduction of saltiness was noted, although the glutamate taste was a normal one.

Jacobs (1948) found that when a solution of salt and glutamate in which the salty taste predominated was diluted, the glutamate taste appeared. Cairncross and Sjöström (1948) also studied the enhancement of sweetness and saltiness in foods and reported that glutamate accentuated sweetness when the latter was near its "optimal value," but at higher values had no great effect. Similarly, when farina and mashed potatoes

were salted with 75 per cent of the "optimal amount of salt," 0.1 to 0.2 per cent monosodium glutamate could supply the remainder, but glutamate alone could not adequately supply salt value to these foods.

It is difficult to find complete agreement among results of previous investigations. The reports undoubtedly reflect differences in interpretation and usage of terms, in sensitivities of the judges employed, and in testing techniques. Further investigation of the effect of glutamate on primary taste sensations seems necessary, not only to help clarify glutamate's mode of action but also to test its enhancement of sucrose sweetness and sodium chloride saltiness.

The study reported here comprises experiments in which supraliminal sucrose and sodium chloride solutions containing subliminal concentrations of monosodium glutamate (MSG) were presented to eight experienced judges of tested sensitivity. The resulting data were subjected to statistical analysis.

EXPERIMENTAL PROCEDURE

The judges used in the study were drawn from the personnel of the Department of Food Technology at the Massachusetts Institute of Technology. The panel was composed of three women and five men, of whom four were non-smokers and four smokers. All judges were experienced in food judging and prior to this study had taken part in an extensive series of threshold tests and in other projects involving monosodium glutamate.

Preliminary tests were conducted to establish subthreshold values for glutamate. It has recently become customary to determine individual taste sensitivity for a particular substance by presenting the judge with a series of solutions in increasing order of concentration, and accepting as his "threshold" that lowest concentration of the solution the taste of which he can positively identify. This method is undoubtedly expedient, but loss of the original concept of the term "threshold" and the tendency to report such "thresholds" on the basis of a single trial have made for confusion and lack of consistency in the literature.

A test of this type is of little use with glutamate. Dilute solutions of this substance produce different taste reactions in different individuals, so that it is difficult to affix the end point of positive identification. To meet this latter problem, triangle tests, Helm and Trolle (1946), were carried out in which one 10-ml. sample of glutamate solution was matched with two similar samples of distilled water. The judges were asked to select the odd sample of each triangle in a series of tests utilizing four different levels of glutamate. The glutamate threshold for the panel was taken as the concentration of that glutamate solution which, in repeated trials, could be distinguished successfully from water. In 24 tests with each of the four glutamate levels, the instances in which the odd sample was identified were as follows:

Glutamate concentration	Instances of identification
0.0007 M	8
0.0010 M	12
0.0015 M	16
0.0025 M	22

The ratio of eight to 24 in the identification of the 0.0005 M glutamate solution is equal to the one-third ratio expected by chance in the triangle type of test. The identification ratio of 12 to 24 for the 0.0010 M glutamate solution does not differ significantly from this chance ratio at the P = 0.05 level, Snedecor (1946). On the other hand, the identification ratios of 16 to 24 and 22 to 24 for the solutions containing 0.0015 and 0.0025 M glutamate, respectively, are greater than the result of chance (P = 0.05) and indicate a degree of consistent recognition by the panel.

In accordance with these results and the arbitrary definition of "threshold" given above, 0.0005 and 0.0010 M glutamate solutions were selected for use with this panel, as representing subliminal concentrations of monosodium glutamate.

On the basis of previous tests with a modification of the U.S.D.A. (1943) threshold test in which these judges had participated, it was possible to select concentrations of sugar and salt that were known to be slightly above threshold level for all the judges and that would be consistently recognized as definitely sweet or salty in taste. Solutions of the following concentrations were employed: sucrose, 0.036 M. 0.044 M, and 0.052 M; sodium chloride, 0.023 M.

Domino Brand pure cane sugar and Accent Brand monosodium glutamate were used in making the solutions. Doubly distilled water prepared in an all-glass apparatus was used throughout.

The tests were conducted in midmorning and midafternoon, at least one hour after the judges had eaten. No attempt was made to control smoking. The triangle type of test was used, Helm and Trolle (1946), the solutions being served in approximately 10-ml. portions in identical, coded beakers. Each triangle consisted of one sample of a pure solution (either sucrose or sodium chloride) and two samples of a mixed solution containing glutamate or, instead, two samples of a pure solution and one sample of a mixed solution. The mixed solutions were equal to the pure solutions with which they were matched, in concentration of sugar or salt, respectively, but contained, in addition, either 0.0005 or 0.0010 M of glutamate. The judge was asked to select the odd sample and, if successful, to tell whether it was more or less concentrated in sweetness or saltiness than the two identical samples. At each test period, three triads were judged, consisting either of all sweet or all salt solutions and utilizing the same level of glutamate throughout. After preliminary trials, each test was given to the eight judges three times, making a total of 24 judgments in each set.

The data so obtained were analyzed to determine whether the results differed significantly from those expected by chance, Snedecor (1946). As is customary in this type of calculation, one-third of the number of "no difference" judgments was added to the number of correct identifications, and two-thirds to the number of incorrect identifications. These adjusted scores were used throughout the subsequent analysis.

RESULTS AND DISCUSSION

The test data are summarized (Table 1). Examination of the results shows that the three samples were judged as indistinguishable in 22 per

cent of the sucrose tests and in 15 per cent of the salt tests. These figures are high, in view of the fact that the judges were aware that each triad contained one odd sample. They may be interpreted as not only affording evidence of the judges' freedom from bias but also as an indication of the ineffectiveness of glutamate in enhancing sweetness or saltiness in many of the instances involved.

TABLE 1

Judgments in Triangle Tests With Pure Solutions of Sucrose or Sodium Chloride and Mixed Solutions Containing Monosodium Glutamate

Sugar or salt in pure solution	MSG in mixed solution	Judgments			Score		
		Total	No difference	Correctly identified	Adjusted[1]	Chance[2]	Chi square[3]
M	*M*						
Sucrose series							
0.036	0.0005	24	5	6	7.7	8	0.0075
0.044	0.0005	24	8	4	6.7	8	0.1200
0.052	0.0005	24	8	4	6.7	8	0.1200
0.036	0.0010	24	3	9	10.0	8	0.4200
0.044	0.0010	24	4	7	8.3	8	0.0075
0.052	0.0010	24	3	7	8.0	8	0.0000
All sugar series		144	31	37	47.3	48	0.0008
Sodium chloride series							
0.023	0.0005	24	5	5	6.7	8	0.1200
0.023	0.0010	24	2	9	9.7	8	0.2700
All salt series		48	7	14	16.3	16	0.0025

[1] Correctly identified judgments plus one-third of the number of no difference judgments.
[2] The chance score expected in a triangle type of test.
[3] Chi square = 3.841 at the P = 0.05 level, Snedecor (1946).

Further proof of glutamate's failure in this respect is apparent when the identification scores for the combinations tested are examined. The adjusted score in every case is close to eight, the pure chance result for the selection of one alternative out of three in 24 trials. The adjusted score for all the sugar-glutamate combinations together is almost identical with that satisfying the chance rule (47.3 *vs.* 48). The adjusted score for all the salt-glutamate combinations together, when compared with the value expected by chance (16.3 *vs.* 16), shows a similar relationship. Conclusive evidence lies in the chi-square values, inasmuch as not one of these approaches the value required for significance (3.841 at P = 0.05).

It may be stated, therefore, that concentrations of glutamate (0.0005 and 0.0010 M) that are just subliminal do not enhance or depress the sweetness of sucrose solutions (0.036, 0.044, and 0.052 M) or the saltiness of sodium chloride solutions (0.023 M) that are just above threshold.

Although the number of correct identifications is not significant, an analysis of their distribution is revealing. A comparison is given (Table 2) for those instances in which the odd sample was correctly distinguished from the two similar samples in each triad. In each instance the pure solution has been used as the basis for the comparison, whether it was the odd sample or the two similar samples. The scores (Table 2), therefore,

indicate whether the judges considered the mixtures as sweeter than (or saltier), or not so sweet as (less salty than), the pure solutions, or as having a taste like MSG.

A casual examination of the data in the fourth column (Table 2) might lead to the conclusion that glutamate enhanced the sweetness of the sucrose solutions. Application of statistical analysis is necessary for a sound interpretation. For this purpose, the 10 instances in which the sucrose-glutamate mixtures were reported as being neither sweeter nor less sweet than the pure solutions, but "like MSG," and the six instances in which the salt-glutamate mixtures were reported as "like MSG," were divided between the other two flavor categories in each case, before analysis.

TABLE 2

Analysis of Correct Identifications

Series and identification	MSG level		Score	
	0.0005 M	0.0010 M	Total	Adjusted[1]
Sucrose series				
Total odd samples identified	14	23	37	37
Mixtures *vs.* pure solutions				
As sweeter	8	11	19	24
As less sweet	5	3	8	13
Like MSG	1	9	10	....
Salt series				
Total odd samples identified	5	9	14	14
Mixtures *vs.* pure solutions				
As saltier	1	3	4	7
As less salty	4	0	4	7
Like MSG	0	6	6	....

[1] Total score "like MSG" distributed equally between total scores for sweeter and less sweet, or saltier and less salty, respectively.

The total scores thus adjusted show that for the sucrose series the mixed solutions were judged as sweeter than the pure solutions in 24 instances, and as less sweet in 13 instances. In the salt series the adjusted scores were seven for "saltier" and seven for "less salty." The judgments of sweeter as opposed to less sweet, and saltier as opposed to less salty, are not significantly greater than might occur by chance ($P = 0.05$). This would indicate that even in those instances where the addition of glutamate brought about a detectable change in the taste of the pure solution, the change was not necessarily in one direction, that is, toward augmenting the original taste, but was rather only a difference. The large number of "like MSG" judgments would point to the conclusion that this difference was the addition of monosodium glutamate taste itself, that is, largely "taste feel."

In this study, the glutamate threshold for the judging panel has not been determined, but the information provided by the preliminary experiments on glutamate shows a range of concentrations within which the threshold should lie. This range is from 0.0010 to 0.0015 M glutamate. Crocker (1948) states that monosodium glutamate is detectable in concentrations as low as 0.03 per cent (0.0018 M) and strong at 0.5 per cent

(0.028 M). Sanders (1948) has reported the value 0.0037 M as being close to, but somewhat above, the threshold and has stressed the need to express thresholds as ranges rather than discrete values.

SUMMARY AND CONCLUSIONS

Eight experienced judges of tested sensitivity were used to determine the possible enhancement of supraliminal sweetness (0.036, 0.044, and 0.052 M sucrose) and saltiness (0.023 M sodium chloride), by subliminal concentrations of monosodium glutamate (0.0005 and 0.0010 M).

Under the conditions outlined and in the dilutions employed, monosodium glutamate had no significant effect on the taste of pure sucrose and sodium chloride. In those several cases where a change in taste was observed, the taste appeared to be that of "glutamate" *per se*, rather than additional sweetness or saltiness.

Threshold values for monosodium glutamate were found to be between 0.0010 and 0.0015 M for the eight judges employed.

ACKNOWLEDGMENTS

The authors are grateful to the judges, students, and staff members of the Department of Food Technology, Massachusetts Institute of Technology, who gave generously of their time to serve on the taste panel.

This investigation was conducted with the assistance of grants-in-aid from the following organizations: American Can Company, Maywood, Illinois; Dow Chemical Company, Midland, Michigan; Nestlé Company, New York, New York; Pillsbury Mills, Inc., Minneapolis, Minnesota; Standard Brands, Inc., New York, New York; and Wilson & Company, Chicago, Illinois.

REFERENCES

Cairncross, S. E., and Sjöström, L. B., 1948. What glutamate does in food. Food Industries 20, 982-983, 1106-1107.

Crocker, E. C., 1948. Meat flavor and observations on the taste of glutamate and other amino acids. Symposium on Monosodium Glutamate sponsored by Quartermaster Food and Container Institute of the Armed Forces and Associates, pp. 25-31. Food and Container Institute, Chicago, Illinois.

Galvin, S. L., 1948. The taste of monosodium glutamate and other amino acid salts in dilute solutions. Symposium on Monosodium Glutamate, pp. 39-44.

Helm, E., and Trolle, B., 1946. Selection of a taste panel. Wallerstein Lab. Commun. 9 (28), 181-194.

Jacobs, M. B., 1948. Sodium glutamate. Am. Perfumer 51, 444-445, 447.

Sanders, R., 1948. The significance of thresholds of taste acuity in seasoning with glutamate. Symposium on Monosodium Glutamate, pp. 70-72.

Snedecor, G. W., 1946. Statistical Methods. Fourth ed. Iowa State Coll. Press, Ames, Iowa.

U. S. Dept. Agr., 1943. Experimental Procedure for Conducting Taste and Smell Tests. Agr. Research Admin., Bur. Human Nutrition and Home Econ. (Mimeo.).

NIACIN CONTENT OF TROPICAL FOODS

CONRADO F. ASENJO
Department of Chemistry and Nutrition, School of Tropical Medicine, University of Puerto Rico

WITH CO-OPERATION OF

ORO DE BORINQUEN SEGUNDO, ANA I. MUÑIZ, AND AIDA M. CANALS
Agricultural Experiment Station, University of Puerto Rico, Río Piedras, Puerto Rico

[Received for publication, May 25, 1950]

Frank cases of pellagra are not common in Puerto Rico. Suárez (1939) reported 13 typical cases of the disease, of which 11 were chronic alcoholics and only two were endemic cases. However, this same investigator states that subclinical cases of pellagra have been frequently observed among his patients. After studying the nutritional status of a typical Puerto Rican rural community, Robinson and Suárez (1947) found that 77 per cent of the subjects failed to receive the minimal amount of niacin needed in their diet, while 53 per cent had less than one-half the recommended allowance. In this last group, clinical evidence of niacin deficiency was exhibited by 26 per cent of the subjects who were suffering from some degree of inflamed papillae of the tongue, while 22 per cent showed mild signs only. These authors concluded that, although the deficiency was not as serious as some of the others observed in this group, it was, nevertheless, fairly widespread. There were a few cases of apparently healed pellagrous skin lesions, but no active case of this disease was seen.

The Committee on Food and Nutrition of the National Research Council (1948) has recommended a daily allowance of 15,000 μg. of niacin for a moderately active man. The average Puerto Rican rural basic diet is principally composed of rice, beans, root crops, dried cod fish, plantain, and a small amount of meat and milk. On the basis of data reported here, this basic diet alone, without meat or dairy products, supplies about 11,250 μg. of niacin per 3,000 calories, which value is not far below that recommended by the National Research Council (1948) for an average active man.

If one considers that these standards are more than liberal for Puerto Ricans, as has been pointed out by Robinson and Suárez (1947), because Puerto Ricans are of lower stature and slighter weight than the continental subjects for which they were devised, it can be concluded that the Puerto Rican basic diet, though somewhat deficient in niacin, is not dangerously low in this nutritional factor; provided, of course, that the adequate amount of calories are consumed.

MATERIAL AND METHODS

Practically all the foods assayed were purchased at various local markets or from street vendors in the San Juan-Río Piedras area and are, therefore, representative of what the consumers buy.

TABLE 1

Niacin Content of Tropical Foods

Material	Common name in Spanish	Description of sample	No. samples tested	Niacin in fresh edible portion		
				Max.	Min.	Av.
				µg./ 100 gm.	*µg./ 100 gm.*	*µg./ 100 gm.*
VEGETABLE PRODUCTS:						
Cereals and Cereal Products:						
Corn (*Zea mays* L.)	Maiz	Fresh from the cob	5	2,040	1,370	1,646
Corn meal (*Zea mays* L.)	Harina de maiz	Native	2	2,340	1,740	2,040
Rice (enriched) (*Oryza sativa* L.)	Arroz del país	Improved. Enriched with premix	4	9,157	8,043	8,582
Rice (polished) (*Oryza sativa* L.)	Arroz pulido	Imported	4	1,850	1,007	1,411
FRUITS:						
Avocado (*Persea Persea* L.)	Aguacate	Ripe	5	1,950	790	1,220
Banana, var. gigante (*Musa sapientum* L.)	Guineo, var. gigante	Ripe	5	513	432	482
Banana, var. apple (*Musa sapientum* L.)	Guineo, var. manzana	Ripe	5	832	526	644
Banana, fig. (*Musa sapientum* L.)	Guineo, niño	Ripe	5	840	670	744
Breadfruit (*Artocarpus communis* Forst)	Panapén	Ripe	5	1,060	850	976
Coco plum (*Chrysobalanus icaco* L.)	Hicaco	Ripe	6	617	422	537
Custard apple (*Annona reticulata* L.)	Corazón	Ripe	5	639	227	453
Genipa (*Genipa americana* L.)	Jagua	Ripe	5	700	420	560
Golden apple (*Spondias dulcis* Frost)	Jobo de la India	Ripe	5	1,580	300	742
Grapefruit (*Citrus maxima* Burm.)	Toronja	Juice	5	370	67	233
Grapefruit (*Citrus maxima* Burm.)	Toronja	Whole edible part	5	710	310	460
Grape, sea (*Coccolobis uvifera* L.)	Uva de playa	Ripe	2	590	510	550
Guava (*Psidium guajava* L.)	Guayaba	Wild variety	7	1,036	571	760
Kanapy, bullace plum (*Melicocca bijuga* L.)	Quenepa	Ripe pulp	5	1,770	1,450	1,590
Lemon (*Citrus limonia* Osbeck)	Limón	Juice of ripe fruit	5	196	70	131
Mamey (*Achras sapota* L.)	Mamey zapote	Ripe	5	340	184	289
Mango (*Mangifera indica* L.)	Mango	Ripe	8	466	169	342
Mesple (*Sapota achras* Mill)	Níspero	Ripe	6	290	127	220
Orange, sour (*Citrus aurantium* L.)	Naranja	Ripe; pulp of fruit	4	205	175	187
Orange (*Citrus sinensis* L.)	China	Ripe; pulp of fruit	5	270	170	240
Papaw (*Carica papaya* L.)	Papaya o lechoza	Ripe	5	640	170	326
"Pepino Angolo" (*Sicana odorifera* Vell.)	Pepino angolo	Ripe	5	1,113	748	970
Pineapple (*Ananas Ananas* L.)	Piña	Ripe	5	322	236	271
Pinguin, Maya Fruit (*Bromelia Pinguin* L.)	Maya	Juice of ripe fruit	3	312	295	305

Pomegranate (*Punica granatum* L.)	Granada	Ripe	5	300	240	260
Pond apple (*Annona glabra* L.)	Cayure	Medium ripe	5	1,180	675	893
Soursop (*Annona muricata* L.)	Guanábana	Ripe	5	1,680	914	1,184
Spanish plum (*Spondias purpurea* L.)	Jobillo	Ripe	3	2,700	1,750	2,340
Star apple (*Chrysophillum cainito* L.)	Caimito	Ripe	7	905	632	790
Strawberries (native) (*Rubus rosaefolius* Smith)	Fresas	Ripe	10	568	272	417
Tamarind (*Tamarindus indica* L.)	Tamarindo	Pulp surrounding seeds; ripe	5	1,660	1,090	1,250
West Indian cherry (*Malpighia punicifolia* L.)	Acerola	Ripe; pulp and skin	3	490	470	480
West Indian locust (*Hymenea courbaril* L.)	Algarrobo	Yellow powder surrounding seeds; ripe	5	4,387	2,910	3,660
VEGETABLES:						
Root Crops:						
Arracacha (*Arracacia xanthorrhiza* Bancroft)	Apio	As sold in the market	6	910	226	431
Carrot (*Daucus carota* L.)	Zanahoria	As sold in the market	4	448	142	336
Cassava (*Manihot Manihot* L.)	Yuca	As sold in the market	5	616	184	402
Corn root, sweet (*Calathea allouia* Aubl.)	Lerenes	As sold in the market	5	358	253	286
Sweet potato (*Ipomoea batatas* L.)	Batata	As sold in the market	5	1,417	624	910
Yam, white (*Dioscorea alata* L.)	Ñame blanco	As sold in the market	6	910	226	431
Yam, yellow (*Dioscorea cayenensis* Lam.)	Ñame amarillo	As sold in the market	5	661	404	573
Yautía, white (*Xanthosoma saggitifolium* L.)	Yautía blanca	As sold in the market	5	690	290	470
Yautía, yellow (*Xanthosoma atrovirens* C.)	Yautía amarilla	As sold in the market	6	1,084	363	934
BEANS:						
Black beans (*Dolichos lablab* L.)	Chícharos	Dried; native	5	3,210	1,310	2,709
Cowpea (*Vigna unguiculata* L.)	Frijoles	Dried; native	4	2,260	1,790	1,960
Chick-pea (*Cicer arietinum* L.)	Garbanzos	Dried; imported	5	1,790	753	1,377
Navy beans (*Phaseolus vulgaris* L.)	Habichuelas blancas	Dried; imported	3	2,990	1,369	2,033
Pigeon pea (*Cajanus cajan* L.)	Gandules	Partly dried; native	5	2,100	860	1,658
Red kidney beans, native (*Phaseolus vulgaris* L.)	Habichuelas coloradas	Dried; native	4	3,469	1,575	2,632
Rose beans (*Phaseolus vulgaris* L.)	Habichuelas rositas	Dried; imported	4	2,233	1,064	1,713
String beans (*Phaseolus vulgaris* L.)	Habichuelas tiernas	Fresh; native	5	940	520	648
GREENS:						
Cucumber (*Cucumis sativus* L.)	Pepino	Fresh	5	286	114	198
Lettuce (*Lactuca sativa* L.)	Lechuga	Fresh leaves	5	620	410	498
Okra (*Abelmoschus esculentus* L.)	Quimbombó	Fresh	5	872	637	728

TABLE 1 *(Concluded)*

Niacin Content of Tropical Foods

Material	Common name in Spanish	Description of sample	No. samples tested	Niacin in fresh edible portion		
				Max.	Min.	Av.
				μg./ 100 gm.	*μg./ 100 gm.*	*μg./ 100 gm.*
Peppers, green (*Capsicum frutescens* L.)	Pimiento verde	Fresh	6	986	473	654
Peppers, sweet (*Capsicum frutescens* L.)	Ajíes dulces	Fresh	3	1,007	426	628
Water cress (*Roripa nasturtium aquaticum* L.)	Berros	Fresh	4	454	323	384
SEEDS:						
Almond, tropical (*Terminalia catappa* L.)	Almendra tropical	Kernel	3	570	483	533
Breadfruit, seed (*Artocarpus integrifolia* L.)	Pepita de pan	Edible part	3	3,160	1,811	2,605
Coconut (*Cocos nucifera* L.)	Coco seco, tela	Flesh from dried coconut	6	922	353	592
OTHER TYPES:						
Calabash (*Crescentia cujete* L.)	Higüera, pulpa blanca	Ripe; white flesh	3	1,460	1,233	1,380
Chayote (*Sechium edule* Jacq.)	Chayote	Ripe	5	500	330	414
Eggplant (*Solanum melongena* L.)	Berenjena	Ripe	5	718	181	424
Onion (*Allium cepa* L.)	Cebolla	Whole	3	184	114	155
Plantain, green (*Musa paradisiaca* L.)	Plátano verde	As sold in the market	5	570	380	446
Plantain ripe, yellow (*Musa paradisiaca* L.)	Plátano amarillo	As sold in the market	5	870	510	680
Squash (*Cucurbita moschata* Duch)	Calabaza	Ripe	5	1,450	560	1,070
Tomato (*Lycopersicon Lycopersicon* L.)	Tomate	Ripe	5	720	460	540
ANIMAL PRODUCTS:						
Dairy Products:						
Cheese (Puerto Rican)	Queso puertorriqueño	Resembles cottage cheese	3	72	67	70
Milk (cow's)	Leche de vaca	Pasteurized (bottled)	3	88	66	76
EGGS:						
Hen's egg (yolk and white) together	Huevo de gallina (yema y clara) juntas	Purchased at random in different markets	3	72	44	61
FISH:						
Dried salted codfish	Bacalao	Imported from Nova Scotia	4	4,333	2,880	3,282

MEAT:						
Beefsteaak	Bistec	Native animals	1	.....	.....	2,007
MISCELLANEOUS:						
Casabe bread	Casabe	A crispy cracker made of meal prepared from cassava	3	982	828	889
Ginger (*Zingiber Zingiber* L.)	Gengibre	As sold in the market	4	1,299	733	1,091
"Guarapo" (*Saccharum officinarum* L.)	Guarapo	Fresh juice from cane	3	94	87	92
Honey (bee's)	Miel de abeja	Local product	1	.....	.....	326
Yeast, *Torula utilis*	Levadura	Manufactured at the pilot plant of "Cía. de Fomento de P.R."	6	22,020	19,210	20,675
"Cáscara de Café"	Cáscara que cubre grano de café	Cuticle from the coffee bean	2	208	182	195
TYPICAL PUERTO RICAN DISHES:						
"Arepa"	Mezcla horneada de harina de maíz, leche de coco, azúcar, y clavo de especie	Baked mixture of corn meal, coconut milk, sugar, and clove	2	988	886	937
"Cazuela"	Mezcla horneada de batata, calabaza, leche de coco, azúcar, y canela	Baked mixture of sweet potato, pumpkin, coconut milk, sugar, and cinnamon	2	826	781	804
"Empanada"	Carne de juey cocida con harina de yuca, leche de coco, y recao	Crab meat cooked with cassava meal, coconut milk, and cooking herbs	2	666	625	646
"Pon de Maíz"	Mezcla horneada de harina de maíz, leche de coco, azúcar, y anís en grano	Baked mixture of corn meal, coconut milk, sugar, and aniseed	2	441	409	425
"Tortilla de yuca"	Harina de yuca cocida y extraída mezclada con azúcar, leche de coco, y especies. Horneada	Boiled and extracted cassava meal mixed with sugar, coconut milk, and species. Baked	2	420	401	411
Basal Puerto Rican rural diet, dried	.....	According to data of Descartes, Diaz Pacheco, and Noguera (1941)	3	1,619	1,425	1,506

Niacin was estimated by the microbiological procedure of Snell and Wright (1941), slightly modified. This modification consisted in substituting enzymatic, hydrolyzed casein for the acid, hydrolyzed casein used in the original method, thus permitting the titration of the tubes in a period of 24 hours. A standard reference trial was run with each batch of medium so as to eliminate any variations due to medium composition. Each sample assayed was tested at four different levels, using duplicate tubes in each level.

The vegetables have been tabulated with the scientific nomenclature accorded to them by Britton and Wilson (1932). The common English names used are those recorded by the last named authors, or by Otero, Toro, and Otero (1945).

SUMMARY

The niacin content of 88 articles of food important in the diet of Puerto Rico and neighboring islands was determined by the microbiological method.

REFERENCES

BRITTON, N. L., AND WILSON, P., 1932. Scientific survey of Puerto Rico and the Virgin Islands. Botany 5, 6, N. Y. Acad. Sciences, New York, New York.

DESCARTES, S. L., DIAZ PACHECO, S., AND NOGUERA, J. R., 1941. Bull. 59, Agr. Expt. Sta., Río Piedras, Puerto Rico.

National Research Council, 1948. Recommended dietary allowances. Reprint and Circ. Series 129, Natl. Research Council, Washington, D. C.

OTERO, J. I., TORO, R., AND OTERO, L. P., 1945. Catálogo de los nombres vulgares y científicos de algunas plantas puertorriqueñas. Bol. 37, Estac. Exptl. Agr., Univ. Puerto Rico, Río Piedras, P. R.

ROBINSON, U., AND SUÁREZ, R. M., 1947. The nutritional status of a Puerto Rican rural community in relation to its dietary intake. P. R. J. Pub. Health Trop. Med. 23, 100-134.

SNELL, E. E., AND WRIGHT, L. D., 1941. A microbiological method for the determination of nicotinic acid. J. Biol. Chem. 139, 675-686.

SUÁREZ, R. M., 1939. El tratàmiento de la pelagra con ácido nicotínico. Bol. Asoc. Med. de P. R. 31, 426-430.

OBJECTIVE AND SUBJECTIVE STUDIES ON FACTORS AFFECTING TOUGHNESS AND STRINGINESS OF KALE *(BRASSICA OLERACEA ACEPHALA)*

KARLA LONGRÉE[1]

AND

FAITH FENTON

New York State College of Home Economics, Cornell University, Ithaca, New York

[Received for publication, May 21, 1950]

Kale has been neglected as a vegetable because many people do not like its characteristic flavor. Furthermore, its texture is often referred to as "tough." Tressler and Evers (1947) stated that frozen kale may be tough and stringy. Smart and Brunstetter (1937) reported that kale was less changed by freezer preservation in color, flavor, and texture than were other vegetables. The wide popularity of kale in the South gives hope that once kale has been accepted, it will become well-liked. In view of the fact that the nutritive value of kale is outstanding, its productive season relatively long, and its cultivation easy, it seems worthwhile to make this vegetable acceptable to more people. Improvements in palatability may be possible through selection of more desirable varieties, maturity and methods at harvesting, storage, preparation, freezing, freezer-storage, and cookery.

According to Thompson (1949), kale varieties grown in the United States belong to two groups, Scotch and Siberian. Greenwood and Salerno (1949) found that Dwarf Blue Scotch Curled and Siberian were well-liked, Dwarf Green Scotch Curled was liked less, and Tall Green Scotch Curled the least. Kale (125 gm.) cooked in medium (312 gm. left) to large (600 gm. left) amounts of water was preferred in general to that cooked in a small amount (25 gm. left). Short (four minutes) or medium (six minutes) cooking times were preferred over long (nine minutes) periods of cooking, but there was a seasonal trend, in that longer cooking was preferred early in the season. No significant differences were found in the flavor scores for kale cooked in water, covered or uncovered, but steamed kale was intensely disliked because of its strong, bitter flavor.

PURPOSE

The purpose of the present project was to study: (1) The nature of toughness and stringiness in kale of four varieties, and to find objective methods of measuring these quality characteristics; (2) the tenderness and stringiness of the different botanical parts; (3) the effect of light frost and of long freezing in the field on the palatability of kale, specifically on toughness and stringiness; and (4) the effect of home freezing procedures

[1] Resident Doctor, 1949, while on sabbatical leave from Hampton Institute, Hampton, Virginia.

and freezer-storage on the palatability of kale, specifically on toughness and stringiness.

TERMINOLOGY

In this report toughness refers to an undesirable degree of firmness of all tissues; stringiness refers to a tendency of certain tissues in the midrib and veins to hang together in strands.

Structurally, a leaf may be divided into three major regions: (1) The epidermis, an impervious layer of cells which covers the entire surface of the leaf and which, in kale, possesses a cuticle; (2) the mesophyll, which is essentially parenchymatous in nature and differentiated into palisade and spongy cells; and (3) the veins, which resemble the vascular bundles of the stem, the middle vein being referred to as midrib. Associated with the vascular elements in the veins are specialized tissues serving as mechanical supports of the blade. These mechanical elements are sclerenchymatous in nature and more or less strong and hard (Fig. 1). The veins branch extensively and become progressively smaller, containing fewer vascular elements until they become very fine veinlets. Ultimately, the divisions of the conducting strands encircle minute areas of the photosynthetic tissue, the so-called vein islets. The fine vascular strands that make intricate contact physiologically with these vein islets lack the sclerenchyma normally associated with the larger bundles, Eames and MacDaniels (1947). The leaves of kale are net-veined.

Toughness of the blade is concerned with the firmness of the epidermis, the mesophyll, and the veins. In palatability tests, it is almost impossible to discriminate between the texture of the area between the veins and that of the veins. Differentiation between toughness and stringiness of the veins is also extremely difficult. Stringiness is more apparent when the texture of the surrounding mesophyll is soft, because of the contrast.

The sensation of stringiness in cooked kale can, theoretically, be brought about in several ways: (1) The veins may be unusually strong; the character of the vascular elements, xylem, phloem, and the supporting mechanical tissue, would therefore deserve study; (2) the mesophyll tissue between the larger veins may be particularly tender or even soft, thus making the network of the veins appear unpleasantly prominent and "stringy," although the veins themselves may not be particularly strong; (3) the network of larger veins may be closely woven. In the latter instance, the area of leaf tissue would contain a relatively large amount of coarse fiber. Stringiness of the midrib can be more easily recognized as a separate characteristic than can toughness. The "strings" can be more or less isolated, in that the judge may pull the test piece through the teeth, thus feeling the strings more acutely (in fact, he can even see them).

HISTORY OF KALE

The following purebred varieties were used: Smooth Kale or Spring Sprouts (Hannover Salad), Long Seasons Kale, Late Seeding Curled Siberian, and Dwarf Blue Curled Scotch Kale.[2] The planting date was August

[2] The seed was a gift from G. Tait, Norfolk, Virginia. According to H. C. Thompson (oral communication), the first three varieties belong to the Siberian type.

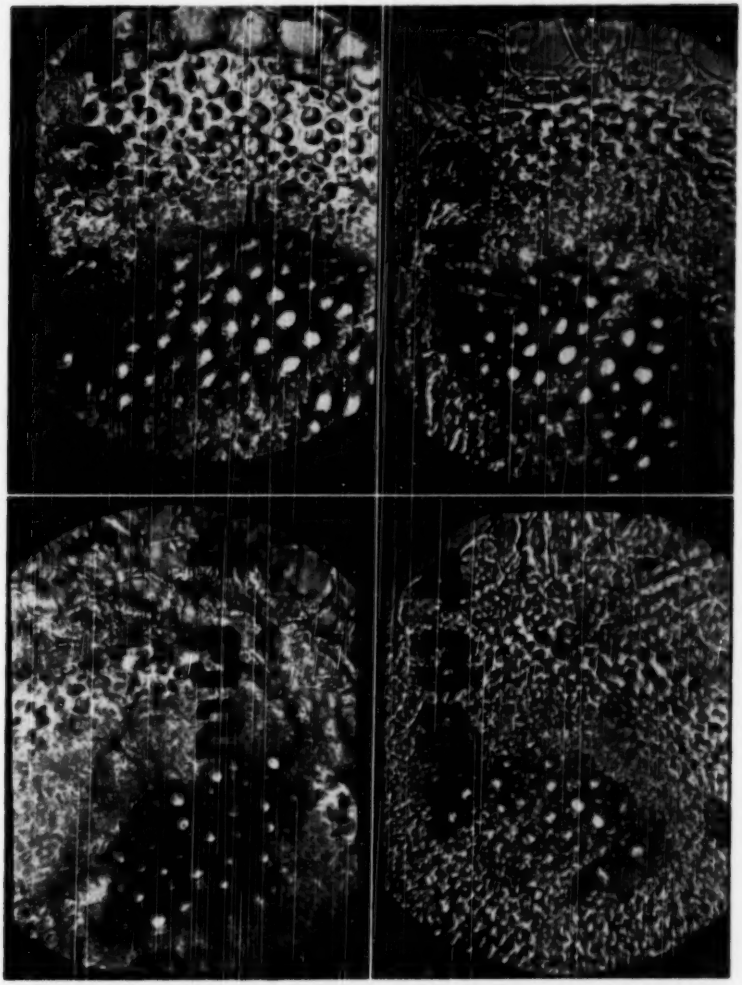


FIG. 1. Part of cross section through major veins of medium leaves of four varieties of kale showing (1) xylem, (2) phloem, (3) sclerenchyma, and (4) parenchyma. a. Smooth Kale; b. Long Seasons; c. Curled Siberian; d. Dwarf Blue Curled Scotch. Stained with phloroglucin. × 210.

3, 1949. The plants were grown in randomized plots on Dunkirk gravelly, sandy loam in the test gardens of the Department of Vegetable Crops, College of Agriculture, Ithaca, New York.[3] The land had received 20 tons

[3] Thanks are herewith extended to Dr. Paul Work for his cooperation.

of manure and 1,500 pounds of 5-10-10 fertilizer per acre. The plot received the routine care given to the test garden. It was irrigated during the hot and dry part of the growing season.

Two light frosts of minmum temperatures of 0°C.(32°F.) and of —1°C. (30°F.) preceded the day (October 12) on which the samples were harvested which were used for the study on the effect of light frost on palatability of kale. No snow fell before that date. Kale used for the study on effect of heavy and prolonged frost was left in the field until December 5. The plants were exposed to freezing 28 times: To minimum temperatures of from 0 to —1°C.(32 to 30°F.) nine times; of from —1.5 to —6.5°C.(29 to 20°F.) 13 times; of from —7 to —12°C.(19 to 10°F.) five times; and of from —12.5 to —18°C.(9 to 0°F.) once. During the period from August 3 to December 5, snow covered the ground for only 10 days. The maximum depth of snow was two and one-half inches.[4] Beginning September 12, young leaves were tagged when they unfurled. Since the rate at which plants grow and mature varies with inherent and environmental conditions, the tagging merely served the purpose of comparing "young," "medium," and "old" leaves within a variety, and corresponding leaves of different varieties. The fact that kale is a cross-fertilizing plant increased the chances for variation between plants of the same variety. In experiments for comparing varieties, "medium" leaves were used which had, on the average, unfurled about three to four weeks prior to cutting. An exception was the leaves harvested from under the snow, which had been tagged six weeks prior to testing. Very little growth occurred during that period and the three-weeks-old leaves were too small to be used for certain tests.

Photographs of a leaf for each of the four varieties are presented (Fig. 2). Smooth kale has smooth, sparsely-veined leaves. The leaves of Long Seasons are larger but also smooth and sparsely veined. Curled Siberian has leaves with delicately curled rims. The centers of the blades are heavily veined, while the edges are quite finely veined. Dwarf Blue Curled Scotch is the most curled of all varieties; the leaves feel hard to the touch and are densely veined, except in the outer, extremely curly portion of the blade.

PROCEDURES

Sampling: All leaves were cut in the morning. A maximum of two leaves was cut from one plant. All leaves used were of similar age. They were brought to the laboratory and washed. Those that had been frozen in the field were allowed to thaw slowly in ice water.

Preliminary treatment in each study was as follows: The midribs were cut out, beginning from the tip, at the point where the midrib assumed a thickness similar to that of the largest vein of that particular leaf. The piece of the midrib used was three inches in length. It seemed unlikely that the homemaker commonly leaves more than two inches of midrib with the blade, in kale prepared for the table. Often she strips the leaves entirely from the midribs. The blades of the kale to be used for palata-

[4] Information on freezing temperatures and on snowfall during the months of October, November, and early December was furnished by the Department of Agronomy at Cornell University (Caldwell Field Station).

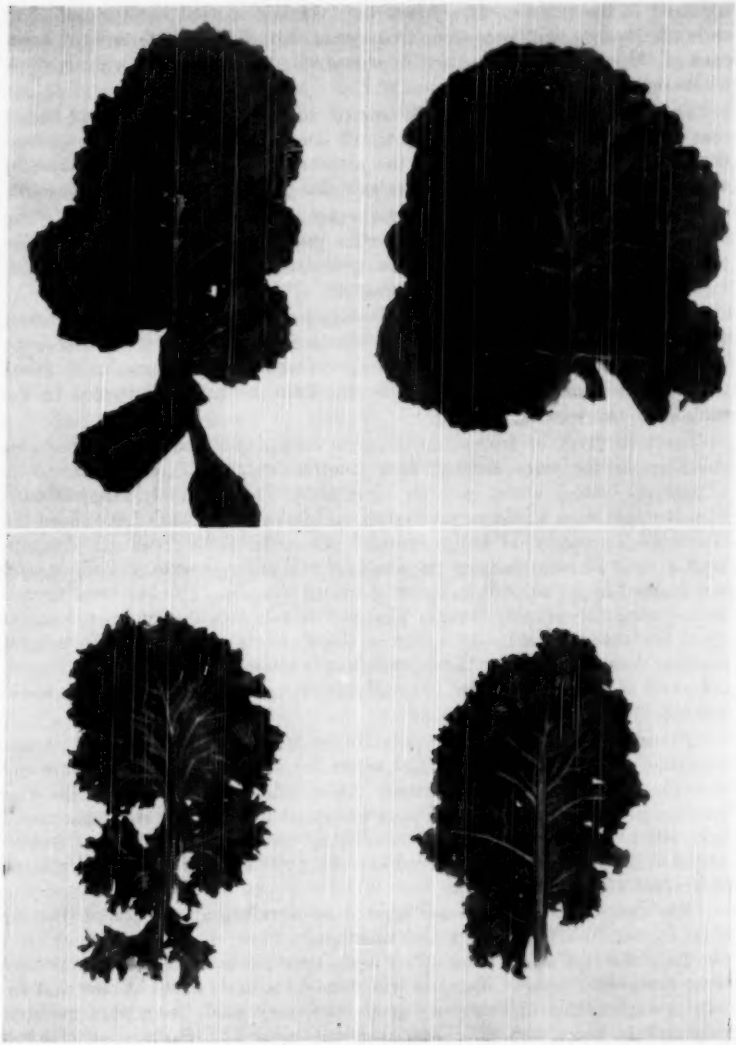


FIG. 2. Medium leaves of kale varieties studied: a. Smooth kale; b. Long Seasons; c. Curled Siberian; d. Dwarf Blue Curled Scotch kale.

bility tests in this study were cut into approximately one-inch squares; the midribs were left in the three-inch lengths.

The samples to be used on the Warner-Bratzler shear apparatus were prepared by cutting pieces four by one inches from each half of the leaf

adjacent to the midrib. The pieces were stacked so that the tip and stem ends alternated, and were tied with string. Of the two samples cut from each of 20 leaves, one was used in one stack; the other in a second stack which served as a replicate.

The midribs were bundled in lots of 10, tips together. It was hoped that the shear values taken on the tip of the midribs would give an indication of the relative hardness of the main veins, and thus might show in which varieties the removal of the midribs prior to cooking is advisable.

Cooking: The kale was boiled in water in a covered enamel pan. The amount of water varied according to the purpose of the experiments. For palatability tests, 250 ml. of water were used for 175 gm. of prepared, fresh kale. Boiling time was six minutes.

For frozen kale, 120 ml. of water were used with 175 gm. of vegetable. Boiling time depended on length of blanching time, but for sake of comparison, the total boiling plus blanching time was always six minutes. Since the water was not sufficient to cover the kale, the kale was turned in the middle of the cooking period.

Samples, fresh or frozen, to be tested on the modified Warner-Bratzler shear apparatus, were dropped into a kettle containing sufficient amounts of rapidly boiling water to cover them well. The relatively large amount of water was used to aid in rapid and uniform penetration of heat into the center of the somewhat bulky samples. In cooking the fresh samples, approximately 15 seconds were required for the water to resume boiling, and approximately 35 seconds in cooking frozen samples. The kale was turned once during the cooking period. The cooked kale was chilled upon removal from the kettle, to stop the action of heat and to insure uniform rate of cooling. Cooking time for the fresh kale was six minutes and for the frozen, four and one-half to one and one-half minutes, depending upon the blanching time used.

Freezing Procedures: For palatability tests, kale in 350-gm. lots was blanched in 6,000 ml. (24 cups) of water for one and one-half minutes and also for four and one-half minutes. After chilling in iced water the kale was weighed and equal weights were packaged in two moisture-vapor-resistant, cellophane-lined, waxed cartons. They were frozen in a home freezer set at −20°C.(−4°F.) and stored at −18°C.(0°F.) until used, after seven and after 12 weeks.

For shear tests, the kale was treated as described above, except that the four by one inch pieces were tied together.

Palatability Tests: Palatability tests were made by a panel of at least four competent judges. Scoring was done on a basis of 10. Color and flavor carried ratings of extremely good (10), very good, good, plus, medium, minus, fair, poor, very poor, and extremely poor (1). Stringiness of blade and of midrib rated no trace (10), trace, slight, plus, medium, minus, fair, stringy, very stringy, and extremely stringy (1). Tenderness of midrib was scored extremely tender (10), very tender, tender, plus, medium, minus, fair, tough, very tough, and extremely tough (1). In rating tenderness of blade different scores were used, according to whether information on degree of tenderness or preferred tenderness was sought. In assigning scores

for tenderness on the basis of preferred tenderness, allowance was made for the fact that a medium tenderness is probably liked best. Medium tenderness was given the highest score (9.5); next were slightly tough and slightly soft (7.5); fairly tough and fairly soft (5.5); very tough and very soft (3.5); and mushy (1.5). When information on degree of tenderness was sought, greatest tenderness was given the highest rating and greatest toughness was given the lowest.

Objective Tests on Toughness and Stringiness, Combined: In objectively testing the tenderness and stringiness of samples, the Warner-Bratzler shear apparatus was chosen. It was used to study possible effects of freezing weather, of home freezing, and of freezer-storage on texture.

The instrument, which is devised to indicate the shearing stress in pounds, proved to have too little sensitivity, and, as a result, very low readings were obtained with cooked kale. Therefore, the instrument was modified by substituting weaker springs for the original ones. As a result, the unit of measurement was changed from 453.6 to 77 gm.

Samples to be tested by shearing were prepared as described above, boiled, and chilled. Each stack of blades was sheared three times, at one-inch intervals. The midribs were sheared twice, one-half inch and one and one-half inches from the tip.

Objective Tests on Toughness: Since palatability and shear tests involved the mesophyll, epidermis, and veins, it seemed advisable to also treat relative tenderness and stringiness as separate factors and to devise tests for them. To test tenderness of the mesophyll and epidermis, a small instrument was necessary which would more or less exclude the possible interference of at least the larger veins. It should be remembered, however, that due to the extensive branching of the veins into finer veins and veinlets, the mesophyll was permeated with these fine endings. Therefore, in piercing the mesophyll between the obvious veins, danger of hitting a more or less large number of veinlets existed. With this in mind, a needle penetrometer was used first. A variety of needles was tried and numerous tests made on stacks of 10, 20, and more small rounds of tissue that had been cut from between the obviously visible veins of cooked kale leaves. Results were extremely variable and therefore unsatisfactory. Some of the difficulties were the following: In a very tough variety none of the layers was pierced, but the layers were pushed together by the weight of the needle. This was expressed as a "reading" on the penetrometer scale, although actually no penetration had taken place. In another variety, the needle penetrated easily through all layers. In a third, in which the mesophyll seemed soft, but in which even the small veins seemed strong and stringy, the needle was sometimes caught by, or found resistance to going through one or the other of these "strings." This happened at almost any point of penetration of a stack of many layers; as a result, the readings were variable, unreliable, and meaningless.

Another puncturing device which eliminated the stacking of several leaves was used next: A pressure tester of the plunger type which has been described by Culpepper and Magoon (1924), and a modification of

which has been used by Kramer, Haut, Scott, and Ida (1949),[5] for the determination of fibrousness in asparagus. The instrument is calibrated to express the pressure in gm. In this study, the blunt round head (12.6 mm.^{2} area) of a small nail was used for a plunger. The force needed to penetrate the islets between the veins was read in gm., and was then calculated to express the pressure per sq. mm.^{2} of surface (Table 1). Uncooked leaves were used in all tests, since the instrument was not sufficiently sensitive to be used on soft, cooked leaves. The leaf to be tested was held firmly and tautly in a small frame. Thirty readings were made on definite areas of each leaf, three medium leaves being used. Four varieties were tested. The results were treated statistically.

Objective Tests on Stringiness: The vascular bundles of veins of cooked leaves were subjected to tensile strength tests. Twenty veins from five medium leaves of similar age, of four varieties of kale, were used. From each leaf, four veins were removed, two from the lower and two from the middle portion of the leaf. Since the veins branched frequently, a small section of vein one cm. long was removed from next to the midribs and prepared for the test. Separation of the vascular bundles from the surrounding parenchymatous tissue, which was done under a binocular microscope, was an extremely tedious task. Usually several bundles were included in a strand.

To determine the tensile strength of these small and delicate strands a special device was arranged. A Harvard tripp balance was raised on a ringstand. A 250-cc. beaker was placed on the right plate. A clamp was hung from the left arm of the scales and a second clamp attached to a ringstand was placed directly under the clamp attached to the balance, so that the vertical distance between the two clamps was one-half cm. The scales were balanced. Tubing which had been attached to a carboy of water placed on a shelf above the scales, was clamped to a ringstand and mounted above the beaker on the scales. The tubing ended in a glass pipette which allowed 200 ml. of water to escape into the beaker per minute. A sample to be tested was fastened between the clamps, and the water allowed to run into the beaker until the sample snapped. The amount of water accumulated in the beaker was measured in ml. The mechanical resistance was then calculated, and expressed as strength per unit of area, namely, gm. of force required to break a strip of vascular area of one square mm. The results were treated statistically. The broken ends were saved and preserved in formalin-aceto-alcohol fixing fluid which contained five parts of formalin, five parts of glacial acetic acid, and 90 parts of 50 per cent ethyl alcohol.

RESULTS AND DISCUSSION

Objective Tests for Determining Tenderness of Blade (Uncooked): According to variety means, Curled Siberian was significantly the most tender variety (Table 1). It was followed by Dwarf Blue Curled Scotch and Long Seasons, the differences between which were insignificant. Smooth Kale variety was significantly the least tender. The leaves of all varieties were significantly most tender at the tip and least tender near the base. In

[5] Thanks are herewith extended to Dr. Amihud Kramer, of the University of Maryland, College Park, Maryland, for loan of the instrument.

Smooth Kale, Curled Siberian, and Dwarf Blue Curled Scotch kale the center portion was significantly less tender than the rim, but in Long Seasons, which is a large-leafed variety, the opposite was true. In palatability tests, the variety Dwarf Blue Curled Scotch received lower scores than the plunger test would indicate. This difference was more an apparent one than a real one, as explained later under tensile strength. The finding is at least partially explained in Fig. 2. This variety has leaves that are densely and heavily veined, except in the outer, curly rim, where the veining becomes fine.

TABLE 1

Tenderness of Four Varieties of Kale, Measured at Different Parts of Leaf With a Plunger

Part of leaf	Means of varieties				
	Smooth Kale	Long Seasons	Curled Siberian	Dwarf Blue Curled Scotch	Av.
Rim	121.9	124.3	106.1	114.2	116.6
Center	133.2	117.4	124.4	126.9	125.5
Tip	119.4	121.4	101.9	106.9	112.4
Outer middle	118.9	124.7	104.4	108.5	114.2
Outer base	127.5	126.7	111.9	126.9	123.3
Upper center	130.0	116.1	124.2	129.7	125.0
Lower center	136.4	118.6	124.7	124.2	126.0
Variety means	126.4	121.5	113.4	119.3	120.2

Tukey test the variety means:

$T_{.05} = 2.0$ $\quad S_m = \sqrt{S^2/90} = 1.5$ $\quad d = 4.3$

Order of variety means:
Curled Siberian 113.4
Dwarf Blue Curled Scotch 119.3
Long Seasons 121.5
Smooth Kale 126.4

Differences:
Dwarf Blue Curled Scotch — Curled Siberian = 5.8 > d
Long Seasons — Dwarf Blue Curled Scotch = 2.2 < d
Smooth Kale — Long Seasons = 4.9 > d

Tensile Strength Tests on Vascular Bundles of Veins, and Histological Observations: Results on the tests of tensile strength of vascular bundles removed from four veins of each of five medium leaves, from five different plants of four varieties, are presented (Table 2). Dwarf Blue Curled Scotch kale showed greater tensile strength values for vascular bundles than did the other three varieties. An analysis of variance on the readings for tensile strength showed that the values for different leaves from Dwarf Blue Curled Scotch were extremely variable. Therefore, a comparison with the other varieties on a statistical basis was not possible. Values of the other three varieties, however, were statistically analyzed. Smooth Kale showed significantly higher tensile strength than Long Seasons. Long Seasons, in turn, was significantly higher in tensile strength than Curled Siberian.

Elements which are constituents of the vascular bundles in the veins and which, therefore, were involved in the tests for tensile strength, were xylem, phloem, mechanical (sclerenchymatous) tissues, and a relatively small number of cambial and parenchymatous cells (Fig. 1). Of these elements, the xylem, because of its lignification—and the heavy-walled sclerenchyma—must have been the strongest one. Unfortunately, the xylem and sclerenchyma are so intimately connected with the rest of the tissues

TABLE 2

Tensile Strength of Vascular Bundles From Veins of Cooked Leaves (20 Readings of Each Variety)

Variety of kale	Mean tensile strength per mm.^{2} of vascular bundle area	Source of variation	D.F.	Mean square	F value
	gm.				
Smooth Kale (Hannover)	447.9	Total	19	2,090.6	.....
		Among leaves	4	383.1	.....
		Error	15	2,545.9	.....
Long Seasons	310.4	Total	19	4,971.6	.....
		Among leaves	4	7,261.9	1.7
		Error	15	4,360.9	.....
Curled Siberian	210.8	Total	19	3,129.6	.....
		Among leaves	4	5,664.5	2.3
		Error	15	2,453.7	.....
Dwarf Blue Curled Scotch	958.7	Total	19	131,504.1	.....
		Among leaves	4	359,337.5**	5.1**
		Error	15	70,748.6	.....

Tukey test the variety means:

$T_{.05} = 2.0$ $\quad S_m = \sqrt{S^2/20}$ $\quad d = T_{.05}$ $\quad S_m\sqrt{2} = 35.6$

Long Seasons — Curled Siberian = 99.6 > d
Long Kale — Long Seasons = 135.5 > d

composing the vascular bundles that they could not be separated and tested independently.

To find a histological basis for differences in tensile strength of vascular bundles from veins of different varieties, cross sections were made of the bundles. The sections were stained with phloroglucin and studied under the microscope. The sclerenchymatous tissues were given special attention. In no case other than that of the xylem was any lignification of tissues observed. Further work is desirable.

In order to check whether tensile strength was related to stringiness, values for tensile strength tests were compared with palatability scores for freedom from stringiness (Table 3). There was, in general, good agreement between palatability scores on stringiness and tensile strength readings. The palatability tests showed that Dwarf Blue Curled Scotch was the stringiest and Curled Siberian the least stringy of the varieties tested. Palatability scores of Smooth Kale and Long Seasons, however, were almost alike; whereas, the tensile strength of the latter variety was lower than that of the former. This might be understood when consideration is given to the fact that it is more difficult for a judge to detect stringiness in less tender leaves than in tender leaves. In a tender, or soft leaf, stringiness is apt to be more obvious because of greater contrast. Long Seasons was, under the conditions of this experiment, found to be more tender than Smooth Kale, and may have been scored as more stringy because of the greater contrast between the texture of mesophyll and veins.

Comparative Tenderness and Stringiness of Freshly-Harvested Kale, Tested Subjectively and Objectively Before Frost, After Light Frost, and After Heavy Frost: Palatability tests and tests on the Warner-Bratzler

shear apparatus were run in duplicate on the same day. On the shear, an increase in readings indicated an increase in shearing stress. Results are presented (Table 3).

The calculation of variance among readings within all blade samples sheared in this study showed that variance was highest in Dwarf Blue

TABLE 3

Effect of Light and Heavy Frost on Tenderness and Stringiness of Cooked Kale, as Judged by Palatability Scores and Shear Stress

Variety	Blade			Midrib				
	Palatability [1]		Shear [2]	Palatability [1]		Shear (lb.) [3]		
	Tenderness	Freedom from stringiness	(lb.)	Tenderness	Freedom from stringiness	Shearing distance from tip		
						½"	1½"	av.
Before frost								
Smooth Kale (Hannover)	3.8 (2.0 to 5.0)	8.5 (7.5 to 9.5)	5.2	4.0 (2.0 to 5.5)	6.0 (3.0 to 10.0)	4.2	6.2	5.2
Long Seasons	6.3 (5.0 to 9.0)	8.0 (7.5 to 9.0)	4.7	4.8 (3.0 to 6.5)	6.0 (3.0 to 7.0)	3.2	7.0	5.1
Curled Siberian	7.3 (5.0 to 9.0)	9.2 (8.5 to 10.0)	4.4	5.0 (4.0 to 7.0)	8.5 (7.0 to 10.0)	2.6	6.6	4.6
Dwarf Blue Curled Scotch	3.8 (2.0 to 5.0)	7.8 (8.5 to 10.0)	8.0	3.0 (1.0 to 6.0)	3.0 (1.0 to 7.0)	4.8	12.0	8.4
Mean	....	....	5.6	....	....	3.7	8.0	5.8
After light frost								
Smooth Kale (Hannover)	....	....	4.3	....	....	4.1	6.2	5.2
Long Seasons	....	....	4.7	....	....	3.2	6.9	5.2
Curled Siberian	6.6 (5.0 to 8.5)	9.3 (8.5 to 10.0)	4.2	4.7 (3.5 to 6.5)	6.0 (5.0 to 8.0)	2.9	6.4	4.7
Dwarf Blue Curled Scotch	4.0 (2.0 to 5.5)	8.1 (7.5 to 9.5)	5.8	2.6 (1.0 to 5.5)	4.0 (2.0 to 6.0)	4.8	12.1	8.5
Mean	....	....	4.8	....	....	3.8	7.9	5.9
After heavy frost								
Smooth Kale (Hannover)	3.5 (2.5 to 5.0)	8.1 (7.0 to 10.0)	4.1	5.3 (1.5 to 7.5)	3.5 (2.0 to 4.0)	4.3	6.3	5.3
Long Seasons	5.0 (4.0 to 6.0)	8.1 (7.0 to 9.5)	3.4	6.3 (3.5 to 8.5)	3.5 (2.0 to 6.0)	3.9	6.6	5.3
Curled Siberian	5.5 (4.5 to 8.0)	8.5 (7.0 to 9.5)	4.7	7.5 (6.5 to 8.5)	3.8 (2.0 to 5.5)	2.7	5.0	3.9
Dwarf Blue Curled Scotch	3.5 (2.5 to 5.0)	7.3 (4.0 to 9.5)	7.3	6.8 (2.5 to 8.0)	2.8 (1.0 to 3.5)	4.9	7.5	6.2
Mean	....	....	4.9	....	....	4.0	6.3	5.2

[1] Figures are averages, with ranges given beneath. The maximum possible palatability score for each characteristic was 10.

[2] For the blade, each figure is an average of six readings.

[3] The midribs were bundled together in lots of 10, tips together and ends together. The bundles were sheared twice, at a distance of one-half inch and of one and one-half inches from the tip. The figures are averages of two readings at each distance.

Curled Scotch. It was next highest in Curled Siberian, followed by Smooth Kale and Long Seasons. Variance within readings of a sample could be due to several causes: To the relative strength or hardness of the vascular bundles as compared with the remaining tissue included in a sample; to density of veining; or to peculiar arrangement of larger veins. When a stack of 20 layers of leaf tissue is exposed to shear stress, at any one of the three places where the sample is sheared, either few or many large veins may be involved. The more force it takes to shear an individual vein, and the softer the mesophyll, the more difference the presence of a few or of many veins will make. Dwarf Blue Curled Scotch proved to have vascular elements of high tensile strength (Table 2); also, the shear value of midribs cut at the tip was high. Curled Siberian had vascular elements of relatively weak tensile strength and the shear value of midribs cut at the tip was low, but the major veins convened in a peculiar fashion (shown Fig. 2). Certain portions of the leaf were heavily veined, while others were not and this variety had an extremely tender blade, especially toward the rim (Table 1). The relatively high variance in shear values found in these two varieties might well be expected from their peculiar leaf morphology.

As described above, the midribs were cut in bundles of 10, and two bundles were sheared twice; at a distance of one-half inch from the tip and again at one and one-half inches from the tip. The average of these two readings was compared with palatability scores. Although statistical treatment of the shear stress readings on midribs was not made, the data are here presented for comparison. The midribs were so much richer in vascular elements than the blades, that hardness of veins should be more easily recognized in the midribs than in the blades.

Before frost palatability scores indicated that the blades and midribs of Curled Siberian were the most tender and the least stringy of all of the varieties. Those of Dwarf Blue Curled Scotch and of Smooth Kale were the least tender. Dwarf Blue Curled Scotch was the stringiest of all varieties. Curled Siberian and Long Seasons were similar and showed low shear stress of both blades and midribs. Smooth Kale followed, and Dwarf Blue Curled Scotch showed highest shear stress.

After light frost palatability tests were made only on the two extreme varieties, Curled Siberian and Dwarf Blue Curled Scotch. Again Curled Siberian rated better than the Dwarf Blue Curled Scotch in tenderness and freedom from stringiness. In shear stress, the Dwarf Blue Curled Scotch blade and midrib were highest; and other three varieties were lower and similar.

After heavy frost, in palatability scores involving the four varieties, Curled Siberian was again somewhat higher in tenderness and freedom from stringiness, while Smooth Kale and Dwarf Blue Curled Scotch were less tender. The last variety was the stringiest; in general, differences between varieties were slight. In shear tests, Dwarf Blue Curled Scotch showed definitely higher stress values of blade and midrib than the other three varieties, which were similar.

It has been reported, Greenwood and Salerno (1949), that kale becomes more tender after frost. In this study, however, palatability scores and shear stress values did not show a tenderizing effect of frost on cooked kale.

TABLE 4

Effect of Freezing Procedures and Freezer-Storage on Tenderness and Stringiness in Cooked Kale, Expressed by Palatability Scores[1]

Variety	Blanching time[2]	Tenderness—Blade				Freedom from stringiness—Blade			
		Unfrozen	Frozen	Stored frozen		Unfrozen	Frozen	Stored frozen	
				7 weeks	12 weeks			7 weeks	12 weeks
	min.								
Curled Siberian	0	5.7 (5.0 to 8.0)	8.9 (8.0 to 10.0)	....	....	9.3 (7.0 to 10.0)	9.0 (8.0 to 10.0)	....	....
	4½	....	....	6.0 (3.5 to 7.5)	6.8 (3.0 to 8.0)	....	....	8.1 (5.0 to 10.0)	8.3 (7.0 to 10.0)
	1½	....	....	5.9 (1.5 to 8.5)	5.8 (3.0 to 8.0)	....	....	7.9 (5.0 to 10.0)	8.1 (7.0 to 10.0)
Dwarf Blue Curled Scotch	0	5.8 (3.0 to 7.0)	7.3 (5.0 to 9.0)	....	....	8.1 (6.0 to 10.0)	7.3 (3.0 to 10.0)	....	....
	4½	....	....	4.3 (2.5 to 7.5)	5.2 (2.0 to 8.0)	....	....	6.7 (2.0 to 7.0)	6.1 (2.0 to 9.0)
	1½	....	....	3.3 (1.5 to 5.5)	4.0 (2.0 to 7.0)	....	....	4.8 (1.0 to 6.0)	5.9 (3.0 to 9.0)
		Tenderness—Midrib				Freedom from stringiness—Midrib			
Curled Siberian	0	6.7 (6.0 to 8.0)	7.3 (5.0 to 9.0)	....	....	6.0 (2.0 to 8.0)	5.5 (1.0 to 9.0)	....	....
	4½	....	....	6.7 (3.0 to 9.0)	7.4 (4.0 to 10.0)	....	....	5.8 (3.0 to 7.0)	6.2 (3.0 to 9.0)
	1½	....	....	5.8 (3.0 to 8.0)	5.6 (2.0 to 8.0)	....	....	5.6 (2.0 to 8.0)	5.0 (2.0 to 8.0)
Dwarf Blue Curled Scotch	0	2.6 (1.0 to 6.0)	4.3 (1.0 to 8.0)	....	....	4.0 (1.0 to 8.0)	3.2 (1.0 to 4.0)	....	....
	4½	....	....	3.7 (2.0 to 8.0)	4.3 (2.0 to 8.0)	....	....	3.9 (2.0 to 6.0)	3.5 (2.0 to 7.0)
	1½	....	....	4.5 (1.0 to 6.0)	4.3 (3.0 to 7.0)	....	....	4.9 (2.0 to 6.0)	3.7 (2.0 to 6.0)

[1] Figures are averages, with ranges given beneath. The maximum possible score for each characteristic was 10. [2] The sum of the blanching time plus the cooking time was the same in each instance.

Effect of Freezing Procedures and Freezer-Storage on Relative Tenderness and Stringiness: Only the two varieties which in preliminary tests showed the greatest differences were tested for palatability. Dwarf Blue Curled Scotch variety was rated less tender and more stringy than the Curled Siberian (Table 4).

Frozen kale of both varieties, tested 24 hours after freezing, scored higher in tenderness of blades and midribs than did those stored after freezing. After seven weeks of storage, the scores were lower. After 12 weeks, scores for tenderness were similar to those of the shorter storage period. Scores for stringiness of blade decreased slightly upon storage, but stringiness of midribs remained rather stationary. Tenderness of the midribs was difficult to judge and scores varied much.

Differences in palatability scores between kale blanched for four and one-half minutes and for one and one-half minutes were insignificant during the relatively short periods of storage used in this experiment.

Blade samples, when tested 24 hours after freezing had, on the average, very similar shear stress values to those of the unfrozen samples (Table 5). It is likely that the texture of the veins which, according to palatability tests, had not changed appreciably after freezing, influenced the shear stress. There were slight increases in shear stress after the first seven weeks of storage. The coefficient of variation was extremely high in this experiment. Values of shear stress for the midribs showed great variation, due to the nature of the material. There was a trend, however, for each variety to show increased shear stress with increased storage. Freezing, as such, did not affect tenderness and stringiness, as judged organoleptically or by shear stress.

Other Palatability Characteristics: Palatability scores were also assembled on some characteristics other than degree of tenderness and stringiness. The scores for preferred tenderness allowed the highest score for medium tenderness, that is, a firm but tender vegetable.

In color, Curled Siberian was generally rated lowest. It tended to discolor along the rim of the blade. The rim portion was exceedingly tender (Table 1) and was, therefore, easily overcooked.

Differences in flavor between the varieties were slight. The judges gave relatively low scores to Curled Siberian in preferred tenderness, because it was judged too soft. Dwarf Blue Curled Scotch was rated low in preferred tenderness because it was too tough.

Prolonged frost had no effect on color and flavor. In Curled Siberian, a very slight improvement of scores due to decrease in softness was noted by the judges; whereas, in Long Seasons, a slight improvement of scores due to increase in tenderness was observed. Since the effect of frost, if any, was an opposite one for the two cases where it was noted, and because of slightness of change, the effect of freezing weather on preferred tenderness was insignificant under the conditions of the experiment.

The effect of freezing procedures on some palatability characteristics other than degree of stringiness are presented (Table 6). No definite effect of the two blanching times on the scores of color, flavor, or preferred tenderness was observed when the combined blanching and cooking times were the same.

TABLE 5

Effect of Freezing Procedures and Freezer Storage on Shear Stress of Cooked Kale

Variety	Shear in pounds[1]															
	Blade				Midrib											
					Unfrozen			Frozen			Stored frozen					
											7 weeks			12 weeks		
	Unfrozen	Frozen	Stored frozen 7 weeks	Stored frozen 12 weeks	Shearing distance from tip			Shearing distance from tip			Shearing distance from tip			Shearing distance from tip		
					½"	1½"	Av.	½"	1½"	Av.	½"	1½"	Av.	½"	1½"	Av.
Smooth Kale	5.2	4.3	6.5	7.1	4.2	6.2	5.2	4.7	6.1	5.4	3.2	9.6	6.4	4.2	10.6	7.4
Long Seasons	4.7	4.8	6.1	5.3	3.2	7.0	5.1	5.3	9.8	7.3	3.7	8.7	6.2	3.9	8.3	6.1
Curled Siberian	4.4	4.8	5.8	6.2	2.6	6.6	4.6	3.7	9.9	6.8	2.5	11.7	7.1	3.9	9.9	6.9
Dwarf Blue Curled Scotch	8.0	8.5	9.9	10.0	4.8	12.0	8.4	5.5	11.9	8.7	6.2	13.4	9.8	6.2	13.8	10.0

[1] Each figure is an average of six readings.

TABLE 6

Effect of Freezing Procedure and Freezer-Storage on Palatability of Kale

Variety	Blanching time	Color				Flavor			
		Unfrozen	Frozen			Unfrozen	Frozen		
			No storage	Storage			No storage	Storage	
				7 weeks	12 weeks			7 weeks	12 weeks
	min.								
Curled Siberian	0	7.0 (4.0 to 10.0)	9.4 (8.0 to 10.0)	....	....	7.7 (4.0 to 9.0)	6.9 (5.0 to 9.0)	....	....
	4½	....	....	8.0 (6.0 to 10.0)	6.3 (5.0 to 10.0)	....	....	6.0 (4.0 to 8.0)	5.5 (2.0 to 7.0)
	1½	....	....	9.3 (9.0 to 10.0)	5.6 (4.0 to 8.0)	....	....	6.9 (5.0 to 8.0)	6.1 (2.0 to 8.0)
Dwarf Blue Curled Scotch	0	8.4 (6.0 to 10.0)	9.2 (9.0 to 10.0)	....	....	6.7 (5.0 to 9.0)	6.6 (5.0 to 9.0)	....	....
	4½	....	....	9.9 (7.0 to 10.0)	7.5 (3.0 to 10.0)	....	....	5.4 (3.0 to 6.0)	5.6 (2.0 to 8.0)
	1½	....	....	9.5 (7.0 to 10.0)	7.9 (5.0 to 9.0)	....	....	5.2 (3.0 to 9.0)	5.8 (4.0 to 7.0)
Average of both varieties	0	7.7	9.3	....	....	7.4	6.8	....	....
	4½	....	....	9.0	6.9	....	....	5.7	5.6
	1½	....	....	9.4	6.8	....	....	6.1	6.0

TABLE 6 *(Concluded)*

Variety	Blanching time	Tenderness of blade							
		Preferred tenderness				Degree of tenderness			
		Unfrozen	Frozen			Unfrozen	Frozen		
			No Storage	Storage			No Storage	Storage	
				7 weeks	12 weeks			7 weeks	12 weeks
Curled Siberian	*min.* 0	7.3 (5.5 to 9.5)	3.8 (1.5 to 5.5)	....	....	5.7 (5.0 to 8.0)	8.9 (8.0 to 10.0)	....	....
	4½	....	....	7.2 (5.0 to 9.0)	6.5 (4.5 to 9.8)	....	....	6.0 (3.5 to 7.5)	6.8 (3.0 to 8.0)
	1½	....	....	7.6 (3.0 to 9.0)	7.1 (4.5 to 9.5)	....	....	5.9 (1.5 to 8.5)	5.8 (3.0 to 8.0)
Dwarf Blue Curled Scotch	0	5.2 (3.5 to 7.5)	5.9 (4.0 to 7.5)	....	....	5.8 (3.0 to 7.0)	7.3 (5.0 to 9.0)	....	....
	4½	....	....	7.0 (5.0 to 9.0)	6.7 (3.5 to 9.5)	....	....	4.3 (2.5 to 7.5)	5.2 (2.0 to 8.5)
	1½	....	....	5.0 (3.0 to 7.0)	6.4 (3.5 to 9.5)	....	....	3.3 (1.5 to 5.5)	4.0 (2.0 to 7.0)
Average of both varieties	0	6.3	4.9	....	....	5.8	8.1	....	....
	4½	....	....	7.1	6.6	....	....	5.2	6.0
	1½	....	....	6.3	6.8	....	....	4.6	4.9

[1] The maximum possible score for each quality characteristic was 10.

Frozen samples received higher scores for color. Scores for color were practically unchanged in samples stored seven weeks, but after 12 weeks the color scores were lower, especially for Curled Siberian. Scores for flavor of this variety were slightly lower in the frozen samples than in the unfrozen. Curled Siberian is originally a mild-flavored variety and after blanching, chilling, and freezing it became more so. The judges frequently commented that frozen samples were "watery" or "too flat." Frozen Curled Siberian variety also received low scores because of undesirable degree of softness.

The Dwarf Blue Curled Scotch kale, which originally is a strong-flavored variety, was scored slightly higher in flavor after freezing. This was probably because of a milder flavor in the cooked frozen kale than in the cooked fresh kale.

Further studies are needed on the tenderness and stringiness of kale, including one on yearly variation.

SUMMARY OF RESULTS

Objective tests with a plunger tester showed that the blade between the veins of the leaves of all varieties was most tender at the tip and least tender at the base. In Smooth Kale, Curled Siberian, and Dwarf Blue Curled Scotch, the center portion of the blade was significantly less tender than the rim, but in the Long Seasons variety the opposite was found. The order of decreasing tenderness of varieties of kale, based on the mean of tenderness as determined with a plunger tester, was: Curled Siberian, Dwarf Blue Curled Scotch, Long Seasons, and Smooth Kale.

Objective tests determining the relative tenderness and stringiness of the blades, exclusive of the midribs, and of the midribs by themselves, by a modified Warner-Bratzler shear apparatus, showed the following order of shear stress from most to least tender: Curled Siberian, Long Seasons, Smooth Kale, and Dwarf Blue Curled Scotch. The same order was found for midribs alone.

In tensile strength tests made on vascular bundles removed from major veins of cooked leaves, the following order from lowest to highest tensile strength was found: Curled Siberian, Long Seasons, Smooth Kale, and Dwarf Blue Curled Scotch.

In palatability tests the blades of Curled Siberian were scored most tender and least stringy; Long Seasons was next in tenderness and in stringiness. Smooth Kale and Dwarf Blue Curled Scotch were judged lowest, and equally so, in tenderness. The last variety was judged the stringiest.

Good agreement was found between tensile strength values, for the vascular bundles from main veins of cooked leaves of the four varieties, and palatability scores.

Good agreement was also found between shear stress values and combined palatability scores for tenderness and stringiness. Evidently, shear values measured both tenderness and stringiness.

The plunger tester, use of which was restricted to measuring the tissues between the veins, was an important tool in determining the tenderness of definite small areas. It aided in the understanding of the nature of toughness of certain varieties.

Light frost or heavy frost had no definite effect on tenderness or stringiness of blades, as judged either organoleptically or by shear stress; the midribs were judged as more tender and more stringy after heavy frost, but shear values remained similar.

In the two varieties tested, freezing at −20°C.(−4°F.) had a slight tenderizing effect on blades and midribs as judged organoleptically. This effect did not show up in the shear tests, which measured the combined effect of tenderness and stringiness. Stringiness of blades and midribs was not affected by freezing.

During the first seven weeks of storage, palatability scores for tenderness of blades decreased, but scores for freedom from stringiness of blades remained similar. Shear values for blades increased. The midribs changed little in tenderness and stringiness, as judged either organoleptically or by the shear test.

After five more weeks of freezer-storage, the palatability scores for tenderness of blades and midribs and for freedom from stringiness of blades and midribs were similar to those recorded after seven weeks of storage. Furthermore, the shear stress values were similar to those reported for frozen kale stored for seven weeks.

The differences in tenderness and stringiness of cooked, frozen kale that had been blanched for four and one-half, and for one and one-half minutes, were slight after the relatively short periods of storage used in this study and with the same total blanching and cooking times.

In palatability tests of four varieties, color was rated lowest in Curled Siberian because of a tendency to discoloration of the rim of the blade. Differences in flavor between varieties were slight. The judges gave relatively low scores to Curled Siberian because of its softness, and to Dwarf Blue Curled Scotch because of its toughness.

No effect of prolonged frost or of blanching time (with total blanching and cooking times the same) on palatability was noted by the judges.

Frozen kale was rated higher in color than unfrozen; a mild flavored variety was rated lower, and a strong flavored variety higher, in flavor. With increased length of storage, scores for tenderness decreased.

REFERENCES

Culpepper, C. W., and Magoon, C. A., 1924. Studies upon the relative merits of sweet corn varieties for canning purposes and the relation of maturity of corn to the quality of the canned product. J. Agr. Research **28**, 403-443.

Eames, Arthur J., and MacDaniels, Lawrence H., 1947. An Introduction to Plant Anatomy. Second ed. McGraw-Hill Book Company, Inc., New York, New York.

Greenwood, Mary L., and Salerno, Rose, 1949. Palatability of kale in relation to cooking procedure and variety. Food Research **14**, 314-319.

Johansen, Donald Alexander, 1940. Plant Microtechnique. First ed. McGraw-Hill Book Company, Inc., New York, New York.

Kramer, Amihud, Haut, I. C., Scott, L. E., and Ida, L. E., 1949. Objective methods for measuring quality factors of raw, canned and frozen asparagus. Proc. Am. Soc. Hort. Sci. **53**, 411-425.

Smart, Helen F., and Brunstetter, B. C., 1937. Spinach and kale in frozen pack. I. Scalding tests; II. Micro-biological studies. Food Research **2**, 151-163.

Thompson, Homer, C., 1949. Vegetable Crops. Fourth ed. McGraw-Hill Book Company, Inc., New York, New York.

Tressler, Donald K., and Evers, Clifford F., 1947. The Freezing Preservation of Foods. The Avi Publishing Company, New York, New York.

EFFECT OF SUPERVOLTAGE CATHODE RAYS ON BACTERIAL FLORA OF SPICES AND OTHER DRY FOOD MATERIALS

BERNARD E. PROCTOR, SAMUEL A. GOLDBLITH, AND HARVEY FRAM[1]

Department of Food Technology, Massachusetts Institute of Technology, Cambridge, Massachusetts

[Received for publication, June 8, 1950]

Because of their nature a number of food materials of great importance to the canning and freezing industries can be sterilized only with difficulty by conventional methods of heat processing. Contamination of these food materials with either mesophilic or thermophilic bacteria in large numbers may be of considerable disadvantage to the food processor.

For some time investigations have been in progress in the Food Technology Laboratories at the Massachusetts Institute of Technology to evaluate the possibilities of a method of processing food and drug materials without the production of heat, i.e., "cold sterilization" by supervoltage, cathode rays, Dunn, Campbell, Fram, and Hutchins (1948), Proctor and Goldblith (1948, 1949), Goldblith and Proctor (1949), and Goldblith, Procter, Hogness, and Langham (1949).

The present investigation was undertaken to determine the effectiveness of supervoltage cathode ray irradiation on the bacterial flora of sugars, starches, spices, and other dry food materials.

IRRADIATION EQUIPMENT

A pressure-insulated Van de Graaff continuous accelerator, operating at three million volts, was used for the production of cathode rays, Trump and Van de Graaff (1948). In this equipment, charges are sprayed from ground onto a rapidly moving belt (3,000 r.p.m.) and carried by this belt to a high-voltage terminal. Electrons are produced by a hot tungsten filament and are then accelerated down the vertical tube through the cathode ray window and impinge on the sample, which is placed beneath the window.

MATERIALS AND BACTERIOLOGICAL TECHNIQUES

All materials were purchased on the open market in Boston.

For subsequent bacteriological examination, 11 gm. of the material to be tested were aseptically transferred to a sterile 250-ml. Erlenmeyer flask containing glass beads, and 99 ml. of sterile, distilled water were added (one to 10 dilution). The flask and contents were shaken by hand intermittently during a five-minute period (approximately 100 times).

Mesophilic aerobes were determined by plating one ml. of the above dilution (or serial dilutions made therefrom) in duplicate on tryptone glucose extract agar as the culture medium. The incubation temperature was 37°C.(99°F.).

Thermophilic aerobes were determined in the same manner, with the exception that the incubation temperature was 55°C.(131°F.). Aerobic spore counts were made by placing the one to 10 dilution of the sample in an autoclave and steaming for five minutes at 100°C.(212°F.), then plating and incubating at 37°C.(99°F.).

The presence of mesophilic and thermophilic anaerobes was qualitatively determined by pipetting one ml. of a one to 20 dilution of the food material into melted liver-veal

[1] Present address: National Dairy Research Laboratories, Inc., Oakdale, Long Island, New York.

agar. The contents of the tubes were mixed by rotation and stratified with nutrient agar. The time of incubation in all cases was three days.

For irradiation purposes, each food material was placed in a cardboard carton measuring 2½ by 2½ by ⅝ inches. Quantities used varied with the densities of the materials and ranged from 20 to 60 gm.

The variation in the quantities of the different materials irradiated was due to the fact that the penetration of cathode rays (electrons) depends upon the accelerating voltage and the density of the material. This may be shown by the following formula, Evans (1947):

$$R_{max} = \frac{0.54\,E - 0.15}{d}$$

where R_{max} equals the maximum range expressed in gm. per square centimeter, E is the voltage expressed in Mev (million electron volts), and d is the density of the material.

The dosages used were 1.33×10^6 rep (roentgen-equivalents-physical) and 2.66×10^6 rep. The maximum time required for these dosages was 15 seconds.

In previous work in these laboratories, it has been found that most of the microorganisms studied have been destroyed by a dosage of from 1.5×10^6 to 2.0×10^6 rep, Dunn *et al.* (1948), Nickerson, Goldblith, and Proctor (1950), and Proctor, Nickerson, and Goldblith (1950). No appreciable rise in temperature takes place under such conditions.

TABLE 1

Effect of Supervoltage Cathode Rays on the Bacterial Content of Various Sugars and Starches

Sample and dosage	Bacteria per gm.[1]			
	Total aerobic count		Aerobic spore count	
	37°C.	55°C.	37°C.	55°C.
Sucrose				
Control	<10	30	.....	35
2.66×10^6 rep	<10	<10	.....	<10
Brown sugar				
Control	50	90	<10	100
1.33×10^6 rep	<10	<10	<10	<10
2.66×10^6 rep	<10	<10	<10	<10
Soy flour				
Control	140,000	11,000	2,000	1,600
1.33×10^6 rep	<10	<10	<10	<10
2.66×10^6 rep	<10	<10	<10	<10
Potato starch				
Control	3,000	3,000	.....	120
2.66×10^6 rep	150	<10	.....	<10
Cornstarch				
Control	3,000	Spreader[2]	.....	.....
2.66×10^6 rep	20	<10	.....	.....

[1] The sign < (less than) indicates no colonies at lowest dilution plated (one to 10). [2] Rapid bacterial growth made counting impossible.

RESULTS AND DISCUSSION

The data (Table 1) indicate the lethal effectiveness of supervoltage cathode rays against both mesophilic and thermophilic aerobic spore-forming microorganisms, as well as the total number of microorganisms present, in various sugars and starches. Relatively small numbers of surviving microorganisms were observed in the case of the materials treated.

The data (Table 2) show that the samples of spices used contained a large number of aerobic thermophilic and mesophilic bacteria. With the

exception of black pepper, all the aerobic thermophilic microorganisms were destroyed by a dosage of 1.33×10^6 rep. In five spice materials, some survival of mesophilic aerobic microorganisms was noted at this dosage. However, a marked reduction in count was observed.

TABLE 2

Effect of Supervoltage Cathode Rays on Total Number of Aerobic Mesophilic and Thermophilic Microorganisms in Some Samples of Spices and Other Dry Food Materials[1]

Sample	Bacteria per gm.			
	37°C.		55°C.	
	Control	Irrad.	Control	Irrad.
Paprika	3,500,000	50	650,000	0
Ginger	4,000,000	600	900,000	0
Tumeric	7,700,000	140	850,000	0
Thyme	750,000	0	20,000	0
Sage	10,000	0	9,000	0
Nutmeg	2,500	0	400	0
Chili powder	2,200,000	0	340,000	0
Black pepper	2,600,000	2,500	300,000	500
Red pepper	9,000,000	200	300,000	0
Onion powder	80,000	0	3,000	0
Garlic powder	100,000	0	0	0
Arrowroot starch	50,000	125	15,000	0
Cornstarch	3,000	0	250	0
Whole egg powder	4,000	0	0	0
Potato starch flour	3,000	0	50	0
Whole milk powder	1,300	0	600	0
Gum Arabic	3,500	140	380	0

[1] Dosage: 1.33×10^6 rep.

In the case of the other dry food materials examined (Table 2), there was complete destruction of aerobic thermophilic microorganisms in each of the six materials examined, complete destruction of the aerobic mesophilic microorganisms in four of the materials, and a low survival count of aerobic mesophilic microorganisms in arrowroot starch and gum arabic.

Anaerobes growing at 37°C.(99°F.) were found in eight of nine spice samples examined, nutmeg being the only exception (Table 3). Irradiation by supervoltage cathode rays for a dosage of 1.33×10^6 rep resulted in the destruction of these microorganisms, as evidenced by testing one ml. of a one to 20 dilution of each of these spices in stratified liver-veal agar. Thermophilic anaerobes were present in only three of the nine spice materials and were destroyed by irradiation according to the test described.

SUMMARY

Various dry food materials and spices were examined microbiologically for their aerobic mesophilic and thermophilic bacterial counts. Nine spice materials were examined qualitatively for the presence of mesophilic and thermophilic anaerobes. The lethal effectiveness of supervoltage cathode rays against the various types of microorganisms in these food materials was determined.

A dosage of 1.33×10^6 rep was found to be effective against these microorganisms in the dry food materials and spices, and to result either in complete destruction or, in a few instances, in the survival of only a relatively few microorganisms.

TABLE 3

Effect of Supervoltage Cathode Rays on the Presence of Mesophilic and Thermophilic Anaerobes in Some Spice Samples[1]

Sample[2]	37°C.		55°C.	
	Control	Irradiated	Control	Irradiated
Tumeric	+[3]	−	−	−
Thyme	+	−	−	−
Sage	+[3]	−	−	−
Nutmeg	−	−	−	−
Paprika	+	−	+	−
Red pepper	+	−	+	−
Black pepper	+	−	−	−
Ginger	+	−	−	−
Chili powder	+	−	+	−

[1] Dosage: 1.33×10^6 rep. [2] A one to 20 dilution of the material was made, and one ml. was pipetted into liver-veal agar; tubes were stratified and incubated for three days. [3] Indicates subsurface colonies, but no gas.

ACKNOWLEDGMENTS

Acknowledgment is made to Professor John G. Trump, Mr. Kenneth W. Wright, and the late Mr. Arthur M. Clarke of the Department of Electrical Engineering, Massachusetts Institute of Technology, for their cooperation in placing the Van de Graaff accelerator at the disposal of the authors.

REFERENCES

Dunn, C. G., Campbell, W. L., Fram, H., and Hutchins, A., 1948. Biological and photochemical effects of high-energy, electrostatically produced roentgen rays and cathode rays. J. Applied Phys. **19**, 605-616.

Evans, R. D., 1947. The Science and Engineering of Nuclear Power, p. 53. Addison-Wesley Press, Inc., Cambridge, Massachusetts.

Goldblith, S. A., and Proctor, B. E., 1949. Effect of high voltage X-rays and cathode rays on vitamins (riboflavin and carotene). Nucleonics **5** (2), 50-58.

———, ———, Hogness, J. R., and Langham, W. H., 1949. Effect of cathode rays produced at 3,000 kilovolts on niacin tagged with C^{14}. J. Biol. Chem. **179**, 1163-1167.

Nickerson, J. T. R., Goldblith, S. A., and Proctor, B. E., 1950. A comparison of chemical changes in mackerel tissues treated by ionizing radiation, Food Tech. **4**, 84-88.

Proctor, B. E., and Goldblith, S. A., 1948. Effect of high voltage X-rays and cathode rays on vitamins (niacin). Nucleonics **3** (2), 32-43.

———, and ———, 1949. The effect of supervoltage cathode rays on the nonenzymatic browning reaction of dried fruits and on chemical compounds pertaining thereto. Science **109**, 519-522.

———, Nickerson, J. T. R., and Goldblith, S. A., 1950. Storage of haddock. Refrig. Eng. **58**, 375-379.

———, Van de Graaff, R. J., and Fram, H., 1942-43. Effect of X-ray irradiation on the bacterial count of ground meat. Research Reports on U. S. Army Quartermaster Contract Projects, July 1942-June 1943, Dept. Food Tech., Mass. Inst. Tech., 217-218.

Trump, J. G., and Van de Graaff, R. J., 1948. Irradiation of biological materials by high energy roentgen rays and cathode rays. J. Applied Phys. **19**, 599-604.

THE CAROTENES OF CANTALOUPES[1]

M. G. VAVICH AND A. R. KEMMERER
Nutrition Department, University of Arizona, Tucson, Arizona

[Received for publication, June 11, 1950]

In recent years considerable interest has been demonstrated in evaluating the biological value of the carotenes of various fruits and vegetables. It is generally agreed that the carotene content of a food, as determined by chemical analysis, cannot be accepted always as the true measure of its biological worth, Beadle and Zscheile (1942).

Carotene data reported in the literature for cantaloupe deal with its chemical evaluation, Smith, Farrankop, Caldwell, and Wood (1944). To our knowledge, studies on the biological value and the nature of the carotenes of cantaloupes have not been reported.

CHEMICAL ANALYSIS OF CANTALOUPE

The cantaloupes were obtained from the Salt River Valley in Arizona, either from the University Farm or from commercial growers. Six or more cantaloupes constituted a sample. Only the edible portion was employed in these tests.

For the quantitative estimation of carotene, 20 gm. of cantaloupe were blended in a foaming mixture of one per cent KOH in 95 per cent ethyl alcohol and petroleum ether. The mixture was further extracted with petroleum ether and the alkali and alcohol removed by washing with water. The ether extract was dried with anhydrous Na_2SO_4 and made to suitable volume. Aliquots were passed through an adsorption column of 97 per cent Na_2CO_3 and three per cent MgO and the amount of carotene in that eluent determined.

A suitable aliquot of the original petroleum ether extract was taken for the chromatographic separation of the carotenoid components. The extract was concentrated under reduced pressure and poured onto a column of Ca $(OH)_2$ wet with petroleum ether. After development of the chromatogram (six to eight hours), the column was pushed out of the glass tube, sectioned, and the components eluted with petroleum ether and ethyl alcohol. After the alcohol was removed by washing with water, the extracts were dried over anhydrous sodium sulphate and read in the Beckman Spectrophotometer.

BIOLOGICAL METHODS

The vitamin A low diet used in these experiments was the same as that used in previous work, Vavich and Kemmerer (1950). Rats of the Sprague-Dawley strain were used. When they were 12 to 14 days old, the regular stock diet was replaced with the basal vitamin A low diet. At 28 days the litters were separated into pairs according to sex and weight. This technique produced rats with uniformly low vitamin A stores. One of the pairs was fed 60 μg. of beta-carotene in Wesson oil daily, by means of a calibrated dropper. The pair mate was fed daily portions of cantaloupe equivalent to 60 μg. of beta-carotene. Each of the pairs was given the same amount of the basal diet. The feeding period was of 14 days' duration and the supplements of cantaloupe were kept frozen during this period. No loss of carotene was detected during the holding period. The rats were killed on the 15th day and the livers removed and analyzed individually for vitamin A by the Carr-Price (1926) reaction. An Evelyn Photoelectric Colorimeter with Filter No. 620 was used to read the blue color. Vitamin A alcohol in chloroform solution was used as the standard in preparing the reference curve.

[1] Presented in part at the 112th meeting of the American Chemical Society, New York, 1947.

Digestibility of carotene was determined according to the method described by Kemmerer and Fraps (1938).

RESULTS

The carotene content of two varieties of cantaloupes (Imperial 45 and V-1) and two selections of one variety (Imperial 45) ranged from 18 to 28 μg. per gm. of the edible portion (30 to 47 I. U. per gm.). Typical values are shown (Table 1).

TABLE 1

Typical Beta-Carotene Values of Arizona-Grown Cantaloupes

Cantaloupe	Beta-carotene
	μg./gm.
Imperial	18.2
450, Arizona Selection of Imperial 45	27.6
V-1—Sample A	19.3
V-1—Sample B	23.7

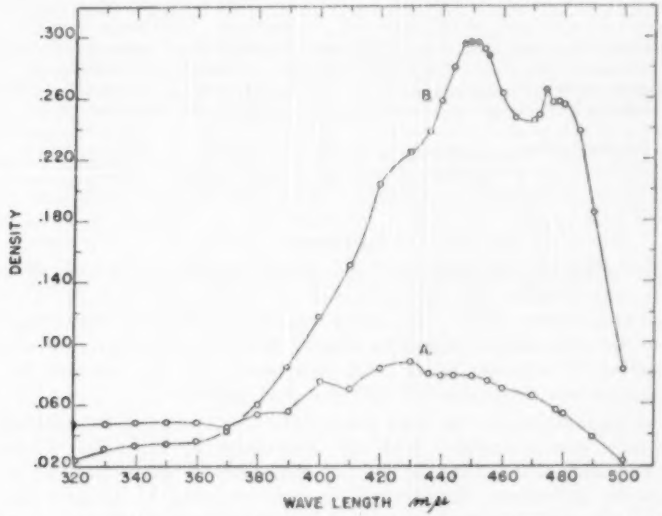


FIG. 1. Absorption spectra of two carotenes obtained from cantaloupes. A. Unknown carotene. B. Beta-carotene.

Chromatographic analysis showed only two pigments (Fig. 1). The major fraction was beta-carotene (B) and consisted of 94 to 97 per cent of the total pigment. The lesser band (A) was strongly adsorbed near the top of the column and showed absorption maxima at 425 to 430 and 405 mμ.

The beta-carotene in the three samples of cantaloupe tested was highly available for storage of vitamin A in the livers of rats. The data (Table 2) show that there was no significant difference in the amount of vitamin A stored in the livers of rats receiving beta-carotene in oil and those receiving

the same amount of beta-carotene in cantaloupe. A new sample of dehydrated alfalfa (310 μg. of beta-carotene per gm.) was run simultaneously with cantaloupe and its carotene showed significantly less availability than the beta-carotene in oil, and significantly less than the beta-carotene in cantaloupe. The succulence of cantaloupe suggested that digestibility may be a factor affecting availability of carotene for storage as vitamin A in the liver. However, the carotene of cantaloupe was 54 per cent digestible, as compared with 51 per cent for alfalfa and 77 per cent for beta-carotene in oil. From these results it appears that digestibility is not a factor. It should be noted that these digestibility values are based on recovery from the feces and do not account for losses through destruction of the carotene in the digestive tract.

TABLE 2

Availability of Beta-Carotene in Cantaloupe

Source of carotene	No. of rats	Vitamin A per liver		t Value
		Range	Mean	
		μg.	μg.	
Imperial 45	21	22.5-77.0	47.0±3.03	0.80
Beta-Carotene in oil	21	10.0-90.0	51.2±4.28	.....
Imperial 45, Arizona	9	15.0-55.0	37.7±5.39	0.58
Beta-Carotene in oil	9	10.0-67.0	42.7±6.68	.....
Alfalfa	12	16.0-46.0	30.8±3.18	4.72
Beta-Carotene in oil	12	32.0-90.0	57.5±5.05	.....
Imperial 45	12	28.0-60.0	48.4±3.60	3.67
Alfalfa	12	16.0-46.0	30.8±3.18	.....

DISCUSSION

The utilization of carotene of cantaloupe appears to be high as compared with certain vegetables reported by Smith and Otis (1941) and Fraps and Meinke (1945). The latter authors reported that the utilization of carotene in certain vegetables ranged from 16 to 64 per cent of the utilization of carotene in oil. Our data show that the carotene in the cantaloupe was approximately 100 per cent utilized.

An explanation for the high availability of the carotene of cantaloupe may have some connection with the observation by Tomarelli, Charney, and Bernhart (1946) that the state of dispersion in which carotene is fed affects its utilization. Similar findings were reported by Halpern, Biely, and Hardy (1947) with chicks, and Sobel, Sherman, Lichtblau, Snow, and Kramer (1948) with rats, in which vitamin A was better utilized when fed as a water emulsion than in a vegetable oil carrier. Since cantaloupe has a water content of 90 per cent and a fat content of 0.2 per cent, such a condition may have some influence upon the biological utilization of the carotene of cantaloupe.

SUMMARY

The carotene content of cantaloupe ranged from 18 to 28 μg. per gm. of edible portion, with at least 94 per cent of the carotene in the form of beta-carotene. Spectrophotometric findings are given concerning an unidentified carotene found in cantaloupes.

There was no significant difference between the availability of the carotene of cantaloupe and the availability of beta-carotene in cottonseed oil for storage of vitamin A in the liver of the rat. The availability of beta-carotene in cantaloupe was significantly higher than the availability of beta-carotene in alfalfa.

REFERENCES

BEADLE, B. W., AND ZSCHEILE, F. P., 1942. Studies on the carotenoids. II. The isomerization of β-carotene and its relation to carotene analysis. J. Biol. Chem. **144**, 21-33.

CARR, F. H., AND PRICE, E. A., 1926. Colour reactions attributed to vitamin A. Biochem. J. **20**, 497-501.

FRAPS, G. S., AND MEINKE, W. W., 1945. Relative values of carotene in foods as measured by storage of vitamin A in livers of rats. Food Research **10**, 187-196.

HALPERN, G. R., BIELY, J., AND HARDY, F., 1947. Utilization of vitamin A in water emulsion. Science **106**, 40-41.

KEMMERER, A. R., AND FRAPS, G. S., 1938. The digestibility of carotene by rats and chickens. J. Nutrition **16**, 309-315.

SMITH, M. C., FARRANKOP, H., CALDWELL, E., AND WOOD, M. A., 1944. The pro-vitamin A and vitamin C values of melons served to the Army and Navy training groups at the University of Arizona. Agr. Sta. Rept. No. 67.

SMITH, M. C., AND OTIS, L., 1941. Observations on carotene analysis of vegetables and fruits as a basis for prediction of their vitamin A value. Food Research **6**, 143-150.

SOBEL, A. E., SHERMAN, M., LICHTBLAU, J., SNOW, S., AND KRAMER, B., 1948. Comparison of vitamin A liver storage following administration of vitamin A in oily and aqueous media. J. Nutrition **35**, 225-237.

TOMARELLI, R. M., CHARNEY, J., AND BERNHART, F. W., 1946. Utilization of intramuscularly injected carotene. Proc. Soc. Exptl. Biol. Med. **63**, 108-110.

VAVICH, M. G., AND KEMMERER, A. R., 1950. Factors influencing the utilization of carotene for storage of vitamin A in the rat. J. Nutrition **40**, 605-610.

NUTRITIONAL VALUE OF PEANUT PROTEIN[1]

EDWARD A. MURPHY AND MAX S. DUNN
Chemical Laboratory, University of California, Los Angeles, California

[Received for publication, June 19, 1950]

The nutritional value of the peanut, as a source of dietary protein, has been the subject of a number of investigations involving humans, dogs, mice, rats, poultry, cattle, sheep, and swine. The majority of these studies has been made with peanut meal, peanut flour, or defatted oil cake rather than with isolated peanut proteins. This fact, together with differences in technique, may account for the variability of the results obtained.

The practical significance of most of the "biological values" and "protein efficiency ratios" may be open to some question, since they are usually determined at about a 10 per cent dietary protein level, and it has been observed that the biological usefulness of even the "poorer" proteins may be increased merely by raising the dietary level. That "protein efficieney" is not necessarily synonymous with growth response, or the latter with over-all physiological value, has also been reported. Amino acid composition data, alone, are not sufficient for the nutritional evaluation of proteins, since the quantitative requirements of animals for the various amino acids are not known.

In the present experiment peanut protein obtained from the Southern Regional Research Laboratory of the U. S. Department of Agriculture was examined for its nutritional value relative to that of beef, rabbit, tuna fish, and casein, as measured by the growth and reproductive response of female mice fed at a 19 per cent dietary protein level. In addition, the effect of supplementation of the peanut protein with lysine and methionine was investigated.

EXPERIMENTAL

1. Preparation and Analyses of the Proteins.

Beef.[2] The cans were opened and warmed to about 80°C.(176°F.). The liquids were decanted and as much visible fat and connective tissue as possible were removed manually. The isolated pieces of beef were rinsed with technical grade ether and ground in a hand meat grinder. The ground meat was dried at 50°C.(122°F.) in an oven for approximately 72 hours. The dried meat was then extracted with aliquots of technical ether until the supernatant was clear. The residue was air- and oven-dried (50°C.) for about four hours. The dry, extracted material was ground in a Waring Blendor and passed through a 30-mesh sieve. The residue was reground in the Blendor and resieved, the final residue being discarded. The resulting material was stored in sealed cellophane bags at −20°C.(−40°F.).

Tuna Fish.[3] The cans were opened and the free oil decanted. The meat was broken into small pieces, rinsed with technical grade ether, and treated in the above manner.

---

[1] Paper 69. For Paper 68, see Camien and Dunn (1950). This work was aided by grants from the Beech-Nut Packing Company and the Nutrition Foundation. The authors are indebted to Dr. M. N. Camien, L. E. McClure, and P. K. Vijayaraghavan for assistance with some of the analyses and assays.

[2] Canned roast beef was furnished by the Continental Can Company through the courtesy of Dr. D. G. Heberlein.

[3] Canned tuna (Chicken of the Sea) was furnished by the Van Camp Laboratories, Terminal Island, California, through the courtesy of Dr. S. Lassen, Director of Research.

Rabbit.[4] The livers, hearts, and kidneys (with perirenal fat) were removed from the dressed carcasses and discarded. The carcasses were autoclaved at 15 lb. pressure for approximately 30 minutes and, after decanting the free liquids, were allowed to cool to room temperature. The principal muscle portions of the legs, back, and chest were removed by hand and treated in the same manner as the beef.

Casein. Vitamin-free casein, approximately 30-mesh particle size, was purchased from General Biochemicals, Inc. This material is hot-alcohol extracted casein.

Peanut Protein.[5] The protein, prepared by the method of Arthur, Crovetto, Molaison, Guilbeau, and Altschul (1948), was ground in a Waring Blendor to 30-mesh particle size.

Elementary analyses of the proteins are given (Table 1) as are the amino acid analyses (Table 2). The latter, with the exception of the values for tryptophan, tyrosine, and cystine, are based on data obtained by the microbiological assay methods used in this laboratory, Dunn, Camien, Eidusson, and Malin (1949a) and Dunn, Camien, Malin, Murphy, and Reiner (1949b).

TABLE 1

Elementary Analysis of Proteins and Calculation of Dietary Levels

Protein	Analysis				Dietary levels		
	Moisture	Ash	Fat	Nitrogen (Kjeldahl)	Protein preparation in diet	Calculated nitrogen level of diet	Protein level of diets (6.25×N)
	pct.	*pct.*	*pct.*	*pct.*	*pct.*	*pct.*	*pct.*
Beef	5.9	2.5	0.33	14.8	20.3	3.00	18.8
Tuna	2.5	9.6	0.06	14.0	21.3	2.99	18.6
Rabbit	3.7	4.3	1.2	14.7	20.4	3.00	18.8
Casein	9.3	1.0	0.1	13.6	22.0	2.99	18.6
Peanut[1]	5.8	0.70	0.06	15.0	20.0	3.00[2]	18.8

[1] The values reported (A. M. Altschul, personal communication) on the dry basis were 16.23 per cent N (three samples, 16.14 to 16.33 per cent) and 0.74 per cent ash (one sample).
[2] Supplementation of Diets F and G with amino acids raised the N values to 3.25 and 3.30 per cent, respectively.

2. Composition of the Diets.

The composition of the purified diets employed is given (Table 3). The casein (Diet D) was supplemented with L-cystine[6] and the peanut protein (Diets F and G) with L-lysine[7] (as the monohydrochloride) and L-methionine[8] (as the DL-form), to provide diets in which these amino acids were present in amounts equivalent to those in the beef diet.

3. Experimental Procedure.

Eighty-four female weanling mice, obtained from A-strain parents which had been raised on the Anderson and Smith (1932) diet, were divided randomly into seven groups of 12 mice each.[9] The 28-day old mice were caged individually and placed on a casein diet (Diet D) for a conditioning period of about two weeks. At the end of this period they were placed on their respective experimental diets and raised to maturity. Growth and food-consumption data were taken during the experiment (Table 4).

[4] Dressed rabbits (New Zealand Whites) were furnished by the Rabbit Experiment Station, U. S. Department of Agriculture, Fontana, California, through the courtesy of Mr. G. S. Templeton, Director, and Dr. E. E. Lund.

[5] Peanut protein was furnished by the Southern Regional Research Laboratory, U. S. Department of Agriculture, New Orleans, Louisiana, through the courtesy of Dr. K. S. Markley, Head, Oil and Oilseed Division, and Dr. A. M. Altschul, Head, Protein and Carbohydrate Division.

[6] The L-cystine was prepared in this laboratory.

[7] L-lysine monohydrochloride was furnished by E. I. du Pont de Nemours & Company through the courtesy of Dr. J. Waddell, Director, the Biological Laboratory.

[8] The DL-methionine was a product of the U. S. Industrial Chemicals, Inc.

[9] Any mouse showing symptoms of respiratory infection was discarded.

TABLE 2

Amino Acid Content of Proteins Calculated to 16 Per Cent Nitrogen

Amino acid	Canned beef	Rabbit muscle	Canned tuna fish	Vitamin-free casein	Peanut protein	Difference $100\frac{\text{peanut-beef}}{\text{beef}}$
	pct.	*pct.*	*pct.*	*pct.*	*pct.*	*pct.*
Arginine	6.3	5.6	5.3	7.3	14.0	+113
Aspartic acid	9.1	10.0	8.4	3.6	12.0	+33
Glutamic acid	15.1	17.0	14.0	23.0	20.0	+33
Glycine	5.8	4.7	4.5	2.0	4.1	−29
Histidine	3.6	2.3	6.0	3.1	2.0	−44
Isoleucine	5.4	5.2	4.9	6.0	4.0	−26
Leucine	8.4	7.9	7.3	10.0	6.7	−20
Lysine	9.6	8.8	8.7	8.0	3.1	−68
Methionine	2.7	2.7	2.8	3.3	1.1	−59
Phenylalanine	4.0	3.8	3.7	5.4	5.4	+35
Threonine	4.6	4.8	4.4	4.3	3.4	−26
Valine	5.4	4.9	5.4	7.3	4.7	−13
Tryptophan	1.3[1]	1.8[2]	1.2[2]	1.2[1]	1.0[1]	.....
Tyrosine	3.4[1]	4.3[2]	3.3[2]	6.9[1]	4.4[1]	.....
Cystine	1.3[1]	1.3[2]	1.3[2]	0.3[1]	1.6[1]	.....

[1] Block and Mitchell (1946-47). [2] Block and Bolling (1945).

TABLE 3

Composition of Diets[1]

Protein source	Group and diet number						
	A	B	C	D	E	F	G
	Canned beef	Canned tuna fish	Cooked rabbit	Vitamin-free casein	Peanut protein	Peanut protein	Peanut protein
Protein material, per cent	20.3	21.3	20.4	22.0	20.0	20.0	20.0
Sure's salts (No. 1),[2] per cent	6.0	6.0	6.0	6.0	6.0	6.0	6.0
Sucrose, per cent	68.5	67.5	68.4	66.6	68.8	67.2	66.6
Vitamins,[3] per cent	0.23	0.23	0.23	0.23	0.23	0.23	0.23
Corn oil, per cent	5.0	5.0	5.0	5.0	5.0	5.0	5.0
L-Cystine, per cent	.....	.....	.....	0.20	.....	.....	.....
L-Lysine. HCl, per cent	.....	.....	.....	.....	.....	1.61	1.61
DL-Methionine, per cent	.....	.....	.....	.....	.....	.....	0.58
Protein, per cent	19	19	19	19	19	19	19
Carbohydrate, per cent	69	68	68	67	69	67	67
Fat, per cent	5	5	5	5	5	5	5
Minerals, per cent	6	6	6	6	6	6	6

[1] The diets are practically iso-caloric, containing 3.9 to 4.0 Cal./gm. of diet, calculated as nine, four, four Cal./gm. for fat, protein, and carbohydrate, respectively.

[2] Sure (1941).

[3] Vitamin mixture, per kg. of diet: Thiamine. HCl, 5 mg.; riboflavin, 10 mg.; pyridoxine, 5 mg.; niacin, 100 mg.; *p*-aminobenzoic acid, 200 mg.; inositol, 1,000 mg.; folic acid, 0.2 mg.; biotin, 0.06 mg.; ascorbic acid, 400 mg.; Ca pantothenate, 20 mg.; choline chloride, 500 mg.; menadione (vitamin K), 1 mg.; *a*-tocopherol, 50 mg.; vitamin A, 20,000 USP units; vitamin D, 2,000 USP units.

At about 16 weeks of age the animals were bred to stock males in groups of not more than six females per male, the experimental diets being maintained during this interval. When obviously pregnant, the females were returned to individual cages and allowed to raise the retained young to weaning age (28 days, postnatal). An attempt

was made to adjust each litter to six young, usually three males and three females. The number and weight of viable young born, the number born dead, the weaning weights of the young, and the weight of the mother at casting and at weaning, were recorded. After weaning, the first-litter young were discarded and the mothers re-bred for second litters. Similar data were recorded for the second litters. After weaning the second litters the mothers were re-bred. Some of the young from the second litters were housed in group-cages containing from two to five young mice per cage and were maintained on their respective experimental diets. Growth and food-consumption data were taken at intervals until the mice were approximately nine weeks of age. The young from the third litters were discarded at weaning.

RESULTS

Growth. The growth and food-consumption data of the parent animals for the approximate period of 6 to 16 weeks of age are summarized (Table 4 and Figs. 1 and 2). Additional growth data from 16 to 40 weeks of age, taken during the reproductive period, are shown in the above-mentioned figures. Data for the second-litter young from four to nine weeks of age are summarized (Table 5 and Figs. 1 and 2).

It would appear from the data (Table 4) that there were no significant differences in the growth-promoting qualities of the seven different diets, whether measured as gain per day, gain per gm. of food, or protein efficiency. It should be noted that the daily consumption of food on the different diets was practically iso-caloric and iso-nitrogenous. Similar con-

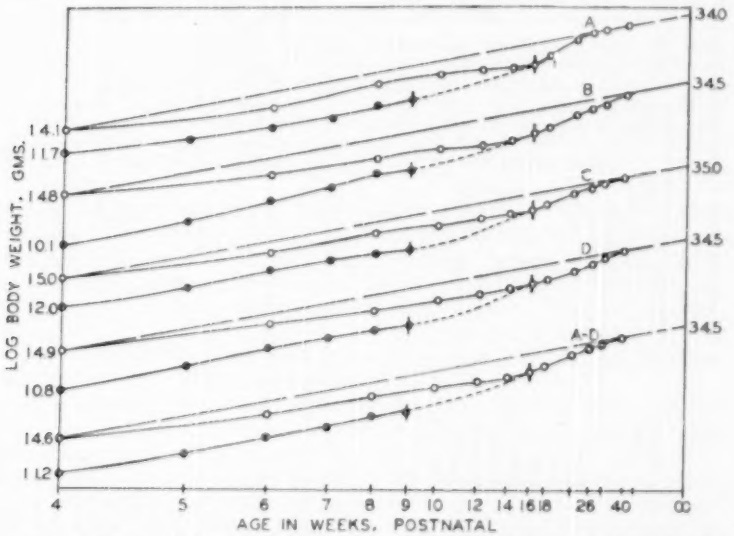


FIG. 1. Curves relating logarithms of body weight and reciprocal age of female mice on various diets. The notations are as follows: The capital letters indicate the Group and Diet designations, A-D indicating the average curves for Groups A through D, the animal protein diet groups. The signs ○—represent data of the parent animals (Table 4); ⓘ—represent data of the second-litter young (Table 5); and ⊕—represent the end of tabulated growth data. The straight lines indicate "adequate" growth curves, Zucker *et al.* (1941). The numbers indicate the initial and limiting weights in gm.

TABLE 4

Growth and Food Consumption Data of Female Mice on Various Diets

Group number	Dietary protein	Number of mice	Age at start of expt'l. regimen	Number of days on expt'l. diet	Wt. at start of expt'l. regimen	Wt. gain on expt'l. diet	Wt. of food eaten	Wt. of food eaten per day	Wt. of protein eaten per day	Cal. consumed per day	Wt. gain per day	Wt. gain per gm. of food	Wt. gain per gm. of protein (protein efficiency)
			days		*gm.*	*gm.*	*gm.*	*gm.*	*gm.*		*gm.*	*gm.*	*gm.*
A	Beef	11	41	62	16.8	6.0	216	3.5	0.66	14	0.097	0.028	0.15
B	Tuna	10	42	64	17.6	5.9	233	3.6	0.69	14	0.092	0.025	0.13
C	Rabbit	12	41	65	18.0	6.9	259	4.0	0.75	16	0.11	0.026	0.14
D	Casein	11	42	66	17.8	6.2	242	3.7	0.70	14	0.094	0.025	0.13
E	Peanut	12	41	67	17.0	7.4	260	3.9	0.74	16	0.11	0.028	0.15
F	Peanut + Lysine	11	42	72	17.7	7.2	281	3.9	0.74	16	0.10	0.026	0.14
G	Peanut + Lysine + Methionine	11	41	71	18.7	7.3	279	3.9	0.75	15	0.10	0.026	0.14

TABLE 5

Growth and Food Consumption Data of Weanling Female Mice on Various Diets

Group number	Dietary protein	Number of mice	Initial age, days	Number of days on experiment	Initial wt.	Wt. gain on experiment	Wt. of food consumed	Duration of measured food consumption	Wt. food consumed per day	Wt. protein consumed per day	Cal. consumed per day	Wt. gained on measured food	Wt gained per day	Wt. gained per gm. of food	Wt. gained per gm. protein (protein efficiency)
					gm.	*gm.*	*gm.*	*da s*	*gm.*	*gm.*		*gm.*	*gm.*	*gm.*	*gm.*
A	Beef	9	29	36	11.9	5.8	77	26	3.0	0.56	12	4.0	0.16	0.052	0.27
B	Tuna	8	28	35	10.2	7.3	78	31	2.5	0.48	9.8	6.4	0.21	0.082	0.43
C	Rabbit	11	30	35	12.2	6.6	105	26	4.0	0.77	16	4.1	0.19	0.040	0.20
D	Casein	11	29	34	10.1	7.7	106	32	3.3	0.63	13	7.1	0.23	0.067	0.35
E	Peanut	7	29	34	7.6	8.7	98	25	3.9	0.74	16	6.6	0.26	0.067	0.35
F	Peanut + Lysine	6	28	34	8.4	8.0	134	30	4.5	0.85	17	6.9	0.24	0.051	0.27
G	Peanut + Lysine + Methionine	10	28	36	10.0	7.5	100	29	3.4	0.66	13	5.8	0.21	0.058	0.31

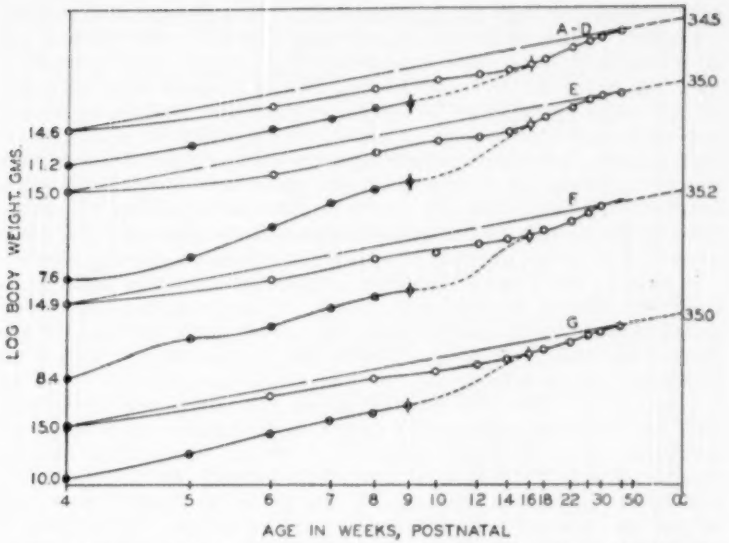


FIG. 2. Curves relating logarithms of body weight and reciprocal age of female mice on various diets. The notations are as follows: The capital letters indicate the Group and Diet designations, A-D indicating the average curves for Groups A through D, the animal protein diet groups. The signs ○—represent data of the parent animals (Table 4); ⊖—represent data of the second litter young (Table 5); and ⊕—indicate the end of tabulated growth data. The straight lines indicate "adequate" growth curves, Zucker *et al.* (1941). The numbers indicate the initial and limiting weights in gm.

clusions may be drawn from results shown (Table 5), although in this experiment there is an increased range of values. The foregoing conclusions are in agreement with the growth curves (Figs. 1 and 2). These curves indicate, however, that none of the diets permitted adequate growth as defined by Zucker's growth formulation, Zucker, Hall, Young, and Zucker (1941).

Reproduction. The averaged reproduction and lactation data for the first, second, and third litters are summarized (Table 6).

It is apparent from the results shown (Table 6) that there was no significant difference in the reproductive and lactational response of the female mice on diets containing beef, rabbit, tuna, or peanut-plus-lysine-plus-methionine as sources of protein. The lactational response of mice on the vitamin-free casein diet, as measured by per cent of young weaned, was below that on the above diets. The diets containing unsupplemented peanut protein or peanut protein plus lysine were deficient in regard to both reproduction and lactation.

DISCUSSION

It may be observed (Table 2) that, relative to beef muscle protein, the peanut protein used herein is deficient in lysine, methionine, histidine,

TABLE 6

Reproduction and Lactation Data Average of Three Successive Litters

Group no.	No. mice	Reproduction					Lactation							
		No. born alive	No. born dead	Av. wt. viable young	Fertility	Viable litters	No. young retained	No. young weaned	Weaned	Weaning wt., gm.		Weight of mother[2], gm.		
										♂	♀	Casting	Weaning	Difference
				gm.	*pct.*	*pct.*			*pct.*					
A	10	7.5	0.2	1.4	100	100	5.8	4.7	81 (79-83)	(72)[1] 12.4	(73)[1] 11.6	30.8	30.0	−0.8
B	8	6.4	0.4	1.3	100	93	5.4	4.4	81 (73-90)	(45) 11.5	(56) 10.8	31.4	31.8	+0.4
C	11	6.5	0.2	1.4	100	97	5.4	4.4	83 (76-88)	(59) 12.2	(63) 11.5	32.6	32.2	−0.4
D	9	6.7	0.4	1.4	100	97	5.5	4.0	72 (60-86)	(49) 12.7	(62) 11.8	32.0	31.8	−0.2
E	9	4.6	1.4	1.3	100	68	4.7	2.8	59 (52-64)	(21) 10.3	(33) 8.8	34.1	31.8	−2.3
F	9	4.0	1.2	1.4	100	79	4.5	2.9	63 (59-68)	(29) 10.4	(37) 9.2	35.4	32.4	−3.0
G	10	6.0	0.1	1.4	100	100	5.4	4.5	84 (72-92)	(51) 11.6	(86) 11.3	31.6	30.9	−0.7

[1] Number of animals. [2] Average of last two litters.

glycine, isoleucine, threonine, and leucine, the degree of deficiency decreasing in that order. The most marked deficiencies are those of lysine and methionine; these, together with threonine and isoleucine, probably are the important deficiencies of peanut protein, since the content of the other low amino acids is within, or very close to, the range of values for the amino acid in the animal proteins listed. Other investigators have reported that peanut protein is deficient in methionine, lysine, and probably threonine and tryptophan and that, when compared to egg protein, it is most deficient in methionine and somewhat less so in lysine, Block and Mitchell (1946-47). It is assumed that the increased content of some amino acids, arginine, aspartic acid, glutamic acid, and phenylalanine in this instance, do not affect adversely the relative nutritional values of the proteins.

In view of studies in this laboratory and others, it would appear there is probably little destruction or loss of availability of amino acids during the processing to which these proteins were subjected. Differences in availability of the amino acids of the different proteins fed are not considered significant, since it has been shown that the true availability to rats of the 10 essential amino acids of cooked beef muscle and of peanut flour proteins is practically equivalent, Kuiken, Lyman, Dieterich, Bradford, and Trant (1948). Possible differences in availability due to physical factors are thought to be alleviated, if not eliminated, by grinding to a 30-mesh particle size, even though this treatment is not sufficient for the most resistent proteins [keratins, Newell and Elvehjem (1947)].

The choice of dietary composition was rather arbitrary. While it has been shown that the differences between "protein efficiencies" are usually greater at the lower levels (5 to 10 per cent) of dietary protein, Barnes, Maach, Knights, and Burr (1945) and Bosshardt, Paul, O'Doherty, and Barnes (1946), a higher level was used in the present experiment, since it was desirable to study reproduction and lactation as well as growth. Previous experience in this laboratory indicated that female mice would reproduce and lactate on a casein diet of the same nature as the one used here. There is, in addition, some evidence that such a casein diet is adequate for the growth of male mice of the Bagg strain, Drell (1949). The inadequacy found for the present mice may be due to a strain and/or a sex difference. That sex and strain differences in nutritional requirements do occur has been definitely established. The fat content of the diet may not be optimal for the most efficient utilization of the proteins, Bosshardt *et al.* (1946) but other things being equal, the caloric intake (approximately 2.0 Cal./gm. Av. $Wt.^{2/3}$/day) would seem to be within a range permitting differentiation of protein values, Bosshardt *et al.* (1948). The composition of the vitamin mixture was that chosen after a review of the literature, Drell (1949), and includes all of the factors known to be required except B_{12}, and the Animal Protein Factors. The salt mixture is one which has been used by Sure (1941) and others with considerable success.

It is apparent (Figs. 1 and 2) that a fairly uniform distribution of animals into the various groups was achieved, with the exception that the animals in Group A were slightly smaller. The relative "inherent sizes" of the animals in the different groups are indicated by the "limiting

weights," Zucker *et al.* (1941) (shown Figs. 1 and 2) and are fairly uniform. That equal distribution of litter mates between the groups was not attained would not seem important since Harte, Travers, and Sarich (1947) have found that groups of nine or 10 randomly chosen weanling rats, selected from groups of 50 or more, gave mean growth response, and variance, of precisely the same order of magnitude as groups from the same stock which were paired with respect to litter. Similar distribution of animals was not compatible with the design of the second growth experiment (Table 5 and Figs. 1 and 2). The difference in initial weights in this experiment reflects lactational deficiencies of the mothers and thus the resulting inverse relative growth rate obtained is a recovery phenomenon and is not indicative of a difference in the nutritive value of the diets.

The experimental procedures used to study reproduction and lactation are similar in many respects to those recommended by Schweigert (1947) and others. It is recognized generally that the nutritional requirements for growth are not necessarily the same as the requirements for reproduction or lactation. A question might be raised as to the practical significance of such tests in the evaluation of diets designed particularly, if not exclusively, for young growing animals (or humans). It would be difficult, if not impossible, to give a completely valid answer to this question. The safest procedure, however, is to elaborate diets adequate for all physiological processes, particularly if this necessitates no great change in processing or cost.

It is obvious that there is no single criterion by which to compare reproductive or lactational responses of different animals, nor is there a satisfactory method of "scoring" such results. According to the data (Table 6), the per cent fertility and the average birth weights were unaffected by the diets used. The average birth-weights appear to be normal for this and some other strains of mice, Fenton and Cowgill (1948). The number of viable young born and the relative number of still-births on the animal protein and the peanut-plus-lysine-plus-methionine diets are markedly different from those on the peanut protein of peanut-plus-lysine diets. It is obvious that the latter two diets are deficient for reproductive purposes. Equally clear-cut results were evident in the lactation data showing per cent weaned, weaning weights, and weight-changes of the mothers. There is no overlap in the ranges of values for per cent weaned, excluding the first litter value for the casein diet (Group D), which was particularly low. A possible explanation for the poorer lactation performance on the casein, relative to the other animal protein diets, is that a 0.20 per cent cystine supplement was used instead of the usual 0.30 per cent supplement of this amino acid. The supplemental level used here was that calculated to equilibrate the cystine content with that of the beef diet, based on analytical values which may not be entirely accurate. Similar results have been obtained by others, using unsupplemented casein. The deficiencies in Diets E and F appear to affect the female more than the male young, since the weaning weights were smaller than the average of the other groups by 22 and 14 per cent, respectively.

The importance of carrying the mice through more than one litter is obvious, since the differences in per cent of young weaned did not become significant until the second litters, and the differences in per cent viability were much greater in the third than in the first and second litters. This is in agreement with the experience of others, Beaty and Fairbanks (1948).

Since it has been found that supplementation with lysine had little effect, while lysine plus methionine raised the dietary value of peanut protein to that of the animal proteins, it might be inferred that supplementation with methionine alone would suffice. It is planned to elucidate this point in a subsequent experiment.

The conclusions drawn from the present experiment agree, in general, with those appearing in the literature. The paper of Daniels and Loughlin (1918), which reported "good" growth of rats on 15 per cent and "normal" growth on 18 per cent peanut protein fed as peanut meal, might be open to the criticism that the early "standards" of growth were low relative to those obtained on modern diets, Dunn, Murphy, and Rockland (1947). Baernstein (1937-38), however, subsequently found that whole defatted peanut, total protein, or total globulin was approximately equivalent to casein in promoting growth of the rat when fed at a 20 per cent level. More recently, Zucker and Zucker (1948) showed that increasing the per cent of peanut flour in a mixture of peanut and white flour (wheat) from 5 to 16 per cent of the mixture (total protein changing from about 17 to 22 per cent), improved the growth of female rats, expressed as per cent of that considered "adequate," from 72 to 90 per cent. Jones (1944) also has stated that raising the dietary level of peanut protein from nine to 15 per cent increased the nutritive value of the diet and reversed the rating of peanut protein relative to soybean protein. Sure (1920), Baernstein (1937-38), and White and Beach (1937-38) are in agreement that arachin, fed at levels from eight to 20 per cent of the diet, is a deficient protein as measured by rat growth. Recently, Sauberlich, Pearce, and Baumann (1948) have indicated the low relative value of arachin when fed to mice at an eight or 10 per cent level. Baernstein (1937-38) reported that, at a 20 per cent level, conarachin yielded satisfactory rat growth and, in disagreement with Sure (1920), that conarachin would supplement arachin for growth purposes. The importance and efficacy of methionine supplementation of an arachin diet is consonant with the results of all of the above investigators. The studies of Irving, Fontaine, and Warner (1945) and Fontaine, Irving, and Warner (1945) would seem to indicate that an isolated peanut protein fraction similar to the one used in this experiment was more representative of the total peanut proteins than either arachin or conarachin. Evidence in agreement with this assumption has been reported by Altschul, Irving, Guilbeau, and Schaefer (1948), who found that isolated peanut protein similar to that used herein, had relatively the same nutritional value as peanut meal when fed as a supplement in chick rations.

Although Daniels and Loughlin (1918) observed that their rats reproduced at frequent intervals and produced three generations of young, no critical study of reproduction and lactation on peanut protein diets appears to have been made. Seeley and Hoffman (1949) reported equivalent fer-

tillity of rats on beef, peanut protein, or yeast diets, at the 20 per cent level, but obtained superior weaning weights on the beef diet. Details of this study do not appear to have been published.

It is somewhat difficult to interpret the results obtained in the present experiment in terms of the contemporary problem of the identity, importance, and function of vitamin B_{12} and the Animal Protein Factor(s). Since no known source of these factors, aside from the proteins themselves, has been incorporated into the diets, it might be assumed that the diets based on isolated peanut protein are relatively free of vitamin B_{12} and/or A.P.F., and that the alcohol-extracted casein used may be relatively low in these factors. One might suppose that the increased mortality of the young on casein, peanut, or peanut-plus-lysine diets, as well as the decreased preweaning growth on the latter two diets, were indicative of deficiencies in B_{12} or A.P.F., but this supposition is negated by the results of supplementation with lysine plus methionine. It may be that peanut protein is not devoid of B_{12}-activity *per se*, since such activity is not limited to animal sources. Luecke, McMillen, Thorp, and Boniece (1949) reported that when added to a corn-soybean meal ration, a B_{12} concentrate improved pig growth, but Cunha, Burnside, Buschman, Glasscock, Pearson, and Shealy (1949a) and Cunha, Hopper, Burnside, Pearson, Glasscock, and Shealy (1949b) found no effect when such a concentrate was added to a corn-peanut meal ration. Schaefer, Salmon, and Strength (1949) have indicated increased growth of chicks when B_{12} is added to an extracted peanut meal-extracted casein diet.

In addition to the probable multiplicity of the growth factors involved and the apparent interrelationships of some of these factors with known vitamins (folic acid, riboflavin, choline, etc.), interpretations are further complicated by the seeming ability of bacteria in the rumen or intestine of various animals to synthesize one or more of these growth factors.

One might venture an interpretation of the results of the present experiment, starting with the similarity of the shapes of the growth curves obtained to that given by Zucker *et al.* (1948) for rats on "Zoopherin" deficient diets. Such interpretation, however, would be entirely speculative and it would seem more profitable to postpone such consideration until vitamin B_{12} and A.P.F. supplementation studies, now under way, have been completed.

SUMMARY AND CONCLUSIONS

Growth, reproduction, and lactation of female A-strain mice have been studied, utilizing purified diets containing beef, tuna, rabbit, casein, peanut, peanut plus lysine, or peanut plus lysine and methionine as sources of protein. All of the proteins were fed at a 19 per cent dietary level.

There were no significant differences in growth response on any of the diets. None of the diets, however, yielded adequate growth as defined by Zucker's growth formulation.

Beef, tuna, rabbit, and casein were equivalent and satisfactory for purposes of reproduction, while casein was somewhat poorer than the other animal proteins for lactational purposes. Peanut protein was deficient both for reproduction and lactation, the deficiency being more apparent in the second and third, than in the first, of three successive litters. Sup-

plementation of the peanut protein with lysine had little, if any, effect on the reproductive or lactational response, but supplementation with lysine-plus-methionine increased the relative value of the peanut protein to that of the beef, tuna, and rabbit diets.

REFERENCES

ALTSCHUL, A. M., IRVING, G. W., GUILBEAU, W. F., AND SCHAEFER, H. C., 1948. The nutritive value of peanut cake, meal, protein, and nonprotein residue for chicks. Poultry Sci. **27**, 402-407.

ANDERSON, W. E., AND SMITH, A. H., 1932. Further observations of rapid growth of the albino rat. Am. J. Physiol. **100**, 511-518.

ARTHUR, J. C., CROVETTO, A. J., MOLAISON, L. J., GUILBEAU, W. F., AND ALTSCHUL, A. M., 1948. Pilot-plant manufacture of peanut protein. J. Am. Oil Chem. Soc. **25**, 398-400.

BARNSTEIN, H. D., 1937-38. The nutritional value of various protein fractions of the peanut. J. Biol. Chem. **122**, 781-789.

BARNES, R. H., MAACH, J. E., KNIGHTS, M. J., AND BURR, G. O., 1945. Measurement of the growth-promoting quality of dietary protein. Cereal Chem. **22**, 273-286.

BEATY, A., AND FAIRBANKS, B. W., 1948. Evaluating the nutritive values of several breads by gestation-lactation performance. Cereal Chem. **25**, 202-213.

BLOCK, R. J., AND BOLLING, D., 1945. The Amino Acid Composition of Proteins and Foods, Springfield, Illinois.

———, AND MITCHELL, H. H., 1946-47. The correlation of the amino acid composition of proteins with their nutritive value. Nutrition Abstracts & Revs. **16**, 249-278.

BOSSHARDT, D. K., PAUL, W. J., O'DOHERTY, K., AND BARNES, R. H., 1946. The influence of caloric intake on the growth utilization of dietary protein. J. Nutrition **32**, 641-652.

———, ———, ———, AND ———, 1948. Caloric restriction and protein metabolism in the growing mouse. J. Nutrition **36**, 773-783.

———, YDSE, L. C., AYRES, M. M., and BARNES, R. H., 1946. The use of mice for the measurement of the growth-promoting quality of proteins. J. Nutrition **31**, 23-33.

CAMIEN, M. N., AND DUNN, M. S., 1950. Antagonisms in the utilization of D-amino acids by lactic acid bacteria. II. J. Biol. Chem. **185**, 553-559.

CUNHA, T. J., BURNSIDE, J. E., BUSCHMAN, D. M., GLASSCOCK, R. S., PEARSON, A. M., AND SHEALY, A. L., 1949a. Effect of vitamin B_{12}, animal protein factor and soil for pig growth. Arch. Biochem. **23**, 324-326.

———, HOPPER, H. H., BURNSIDE, J. E., PEARSON, A. M., GLASSCOCK, R. S., AND SHEALY, A. L., 1949b. Effect of vitamin B_{12} and APF supplement on methionine needs of the pig. Arch. Biochem. **23**, 510-512.

DANIELS, A. L., AND LOUGHLIN, R., 1918. Feeding experiments with peanuts. J. Biol. Chem. **33**, 295-301.

DRELL, W., 1949. Inhibitory analogues of pantothenic acid. Thesis, Univ. Calif., Los Angeles, California.

DUNN, M. S., CAMIEN, M. N., EIDUSON, S., AND MALIN, R. B., 1949a. The nutritive value of canned foods. I. Amino acid content of fish and meat products. J. Nutrition **39**, 177-186.

———, ———, MALIN, R. B., MURPHY, E. A., AND REINER, P. J., 1949b. Percentages of twelve amino acids in blood, carcass, heart, kidney, liver, muscle, and skin of eight animals. Univ. Calif. Publ. Physiol. **8**, 327-332.

———, MURPHY, E. A., AND ROCKLAND, L. B., 1947. Optimal growth of the rat. Physiol. Rev. **27**, 72-94.

FENTON, P. F., AND COWGILL, G. R., 1948. Nutrition of the mouse. VII. Lactation performance of four strains maintained on stock rations. Proc. Soc. Exptl. Biol. Med. **68**, 58-60.

FONTAINE, T. D., IRVING, G. W., AND WARNER, R. C., 1945. Electrophoretic investigation of peanut proteins. II. Composition of several peanut-protein fractions. Arch. Biochem. **8**, 239-249.

HARTE, R. A., TRAVERS, J. J., AND SARICH, P., 1947. Protein assay by rat growth: a comparison of (a) litter mates vs. randomly selected males, and (b) moderate restriction of food intake vs. *ad libitum* feeding. J. Nutrition **34**, 363-372.

IRVING, G. W., FONTAINE, T. D., AND WARNER, R. C., 1945. Electrophoretic investigation of peanut proteins. I. Peanut-meal extract, arachin, and conarachin. Arch. Biochem. **7**, 475-489.

JONES, D. B., 1944. Nutritive value of soybean and peanut proteins. Federation Proc. **3**, 116-120.

KUIKEN, K. A., LYMAN, C. M., DIETERICH, S., BRADFORD, M., AND TRANT, M., 1948. Availability of amino acids in some foods. J. Nutrition **36**, 359-368.

LUECKE, R. W., MCMILLEN, W. N., THORP, F., AND BONIECK, J. R., 1949. The effect of vitamin B_{12} concentrate on the growth of weanling pigs fed corn-soybean diets. Science **110**, 139-140.

NEWELL, G. W., AND ELVEHJEM, C. A., 1947. The nutritive value of keratin. III. Effect of source, particle size, and method of grinding. J. Nutrition **33**, 673-683.

SAUBERLICH, H. E., PEARCE, E. L., AND BAUMANN, C. A., 1948. Excretion of amino acids by rats and mice fed proteins of different biological values. J. Biol. Chem. **175**, 29-38.

SCHAEFER, A. E., SALMON, W. D., AND STRENGTH, D. R., 1949. Relation of vitamin B_{12} to choline requirement of the rat and chick. Federation Proc. **8**, 395.

SCHWIMMER, B. S., 1947. Recent studies on nutritional requirements during reproduction and lactation. J. Am. Dietet. Assoc. **23**, 936-940.

SEELEY, R. D., AND HOFFMAN, H. A., 1949. Value of seven protein sources for growth, reproduction, and lactation in rats fed purified diets. Abstracts 115th ACS Meeting, San Francisco, p. 33c.

SURE, B., 1920. Amino acids in nutrition. I. Studies on proline: Is proline a growth-limiting factor in arachin (globulin from the peanut)? J. Biol. Chem. **43**, 443-456.

———, 1941. Dietary requirements for fertility and lactation. XXIX. The existence of a new dietary factor essential for lactation. J. Nutrition **22**, 499-514.

WHITE, A., AND BEACH, E. F., 1937-38. The role of cystine, methionine, and homocystine in the nutrition of the rat. J. Biol. Chem. **122**, 219-226.

ZUCKER, L., AND ZUCKER, T. F., 1948. Zoopherin: A nutritional factor for rats associated with animal protein sources. Arch. Biochem. **16**, 115-129.

ZUCKER, T. F., HALL, L., YOUNG, M., AND ZUCKER, L., 1941. The growth curve of the albino rat in relation to diet. J. Nutrition **22**, 123-138.

———, AND ZUCKER, L., 1943. Nutritive value of cotton, peanut, and soy seeds. Ind. Eng. Chem. **35**, 868-872.

FOOD RESEARCH

AUTHOR INDEX, VOLUME 15, 1950

Aschehoug, Valborg 62
Asenjo, Conrado F. 103, 326, 465
Andreassen, Ella Gleim 237
Ayres, J. C. 343

Beuk, J. F. 302
Bialek, Henry F. 232
Bouthilet, Robert J. 322
Brooks, Robert F. 8
Burger, H. C. 340
Burke, M. V. 343

Canals, Aida M. 465
Causey, Kathryn 237, 249, 256
Chang, Irene 313
Charley, Helen 155
Clarenburg, A. 340
Coffey, Ruth E. 373
Cowgill, George R. 179

Davey, Bessie L. 373
Davis, Dorothy S. 200, 216
Dunn, Max S. 498

Eagle, Edward 232
Esselen, William B., Jr. 114

Fabian, F. W. 125, 135, 138, 415
Fellers, Carl R. 114
Fenton, Faith 237, 249, 256, 471
Fram, Harvey 490
Freeman, A. F. 146, 297
Fried, J. F. 302

Gainer, Jean Murray 459
Goldblith, Samuel A. 490
Gough, Helen W. 308
Greenwood, Mary L. 223
Guild, Louise P.
16, 34, 263, 355, 379, 421, 439

Harris, Robert S.
16, 34, 79, 263, 355, 379, 421, 439
Hausrath, Mary Elizabeth 237, 249, 256
Henderson, R. H. 415
Holmes, Arthur D. 99
Hummel, Miriam 405

Jack, E. L. 200, 216
Jansen, Erling 62

Kaplan, A. M. 114
Kelley, Lucille T. 263, 379, 421, 439
Kemmerer, A. R. 494
Kocholaty, R. 347
Krehl, W. A. 179

Lamden, Merton P. 79
Lantz, Edith M. 308
Lee, Frank A. 8
Levy, Hilton 192
Lockhart, Ernest E. 459
Longrée, Karla 471

McNally, Ann M. 379, 439
Miller, John I. 8
Morse, Lura M. 200, 216
Morse, Roy E. 454
Moscoso, Carlos G. 103
Muñiz, Ana I. 326, 465
Munsell, Hazel E.
16, 34, 236, 355, 379, 421, 439
Murdock, D. I. 107
Murphy, Edward A. 498

Nebesky, Edward A. 114
Nightingale, Gertrude 16, 34, 263
Nitchals, Ruth M. 373
Nutting, G. C. 331

Ogilvy, W. S. 343
Okey, Ruth 405
Owen, Royene F. 53, 169

Pearson, A. M. 8
Potgieter, Martha 223
Powers, John J. 454
Proctor, Bernard E. 490

Quintana, María Leonor 326

Ramstad, Paul E. 237, 249, 256
Reinhart, Robert 192
Rice, E. E. 302
Romanoff, Alexis L. 1

Schade, Arthur L. 192
Segundo, Oro de Borinquen 465
Singleton, W. S. 146, 297
Stevenson, A. E. 150
Storvick, Clara A. 373

Troescher, Cynthia B. 16, 34, 263, 355

Underwood, J. C. 366

Van Duyne, Frances O. 53, 169
Vavich, M. G. 494
Volz, Frances 8

Wallerstein, James S. 192
Ward, T. L. 146
Watts, Betty M. 313
Weiser, H. H. 91
Wethington, Mary Catherine 125, 135, 138
White, Jonathan W., Jr. 68
Whittenberger, R. T. 331
Williams, Carl J. 454
Williams, Louis O
16, 34, 263, 355, 379, 421, 439
Winter, A. R. 91
Wolfe, Jean Chase 53

Yushok, W. D. 1

SUBJECT INDEX, VOLUME 15, 1950

Appearance of beef, effect of freezing rate on 8
Apples, composition of volatile fraction of 68
Ascorbic acid
  browning of, in pure solutions 79
  content of the West Indian cherry 103
  in foods served in institutional quantities 373
  in kale, as influenced by cooking 223
  losses in concentrated canned tomato products 405
Atmospheres, control of, for use in food research 343
Asparagus, rutin content of 150

Bacterial and chemical analyses of mayonnaise, salad dressing, and related products ... 138
Bacterial flora
  of frozen egg products 91
  of spices, effect of supervoltage cathode rays on 490
Baking pan material, effects of heat penetration on quality of cakes made with fat 155
Beef, palatability and nutritive value as influenced by thawing and cooking method ... 249
Browning of ascorbic acid in pure solutions 79

Cakes
  made with fat, quality of, effect of baking pan material on heat penetration 155
  quality of freshly baked, thawed frozen, and prepared from frozen batters 169
Canned foods, studies on putrefactive anaerobes as spoilage agents in 62
Canned peaches, ropiness in, caused by *Leuconostoc mesenteroides* 415
Canned tomato products, relation of concentration to storage losses of ascorbic acid ... 405
Cantaloupes, carotenes of 494
Carotenes of cantaloupes 494
Cathode rays, supervoltage, effect on bacterial flora of spices and other dry materials 490
Central America, composition of foods of; *see* Composition of food plants of Central America and under various countries
Changes in metabolic characteristics of white potato as affected by conditions of storage 192
Chemical analyses of mayonnaise, salad dressing, and related products 138
Chemical composition of California commercial tomato paste 366
Chicken flavor, separation and concentration of its volatile components from broth 322
Citrus products, vitamin content of 179
Clostridium botulinum, spores of, in Georgia soil 454
Composition of food plants of Central America
  Costa Rica 379
  El Salvador 263
  Guatemala 16, 34
  Honduras 421
  Nicaragua 355
Concentrates, of fruit, microbiological oxidation of ethanol in 347
Concentration of canned tomato products, effect on storage losses of ascorbic acid 405
Cooking method, influence on ascorbic acid and thiamine content of kale 223
Costa Rica, composition of food plants of 379

Darkness prolongs storage life of butternut squashes 99
Detergents, use in preventing mold growth in intact eggs 1
Duck's eggs, survival of *Salmonellae* in 340

Effect of
  monosodium glutamate on taste of pure sucrose and sodium chloride 459
  single and repeated doses of gossypol on the rat 232
  supervoltage cathode rays on bacterial flora of spices and other dry materials 490

Effect of *(Continued)*
thawing and cooking methods on palatability and nutritive value of frozen ground meat
beef ... 249
lamb ... 256
pork ... 237
Egg products, bacterial flora in frozen ... 91
Eggs, mold growth in, prevention by treatment with cationic detergent ... 1
El Salvador, composition of food plants of ... 263
Ethanol, microbiological oxidation of, in volatile fruit concentrates ... 347
Expansibility and specific volume of stabilized and unstabilized peanut butter ... 297

Factors affecting toughness and stringiness of kale ... 471
Factors influencing quality of California tomato paste ... 366
Fats, rancidity of, as affected by salt and moisture ... 313
Flat-sour organisms in tomato juice, inhibitory action of citric acid ... 107
Folic acid-depleted rats, growth response to supplementation with tropical foods ... 326
Food plants of Central America, composition of; *see* Composition of food plants of Central America and under various countries
Food-poisoning *Staphylococci* and *Salmonellae*, viability of, in salad dressing and mayonnaise ... 125
Food research, controlling atmospheres for use in ... 343
Foods
acid, thermal destruction and stability of peroxidase in ... 114
served in institutional quantities, reduced ascorbic acid content of ... 373
Freezing, effect on retention of riboflavin in vegetables ... 53
Freezing rate, effect on appearance, palatability and vitamin content of beef ... 8
Frozen baked cakes, comparison of quality with that of freshly baked cakes and those prepared from frozen batters ... 169
Frozen egg products, bacterial flora of ... 91
Frozen ground meat, palatability and nutritive value of, as influenced by thawing and cooking methods
beef ... 249
lamb ... 257
pork ... 237

Gel strength, effect on non-fat dry milk solids in food preparation ... 200
Georgia soil, spores of *Clostridium botulinum* in ... 454
Gossypol, effect of single and repeated doses on the rat ... 232
Growth response of folic acid-depleted rats to supplementation with tropical foods ... 326
Guatemala, composition of food plants of ... 13, 34, 439

Heat capacity of stabilized peanut butter ... 146
Heat penetration, in cakes made with fat, effect on baking pan material ... 155
Honduras, composition of food plants of ... 421

Influence of cooking method on ascorbic acid and thiamine contents of kale ... 223
Inhibitory action of citric acid on tomato juice flat-sour organisms ... 107
Institutional quantities, of foods served, reduced ascorbic acid content of ... 373

Kale
ascorbic acid and thiamine content as influenced by cooking method ... 223
objective and subjective studies on factors affecting toughness and stringiness of ... 471

Lamb, palatability and nutritive value as influenced by thawing and cooking methods 256
Leuconostoc mesenteroides as the cause of ropiness in canned peaches ... 415

Mayonnaise
bacterial and chemical analyses of ... 138
viability of food-poisoning *Staphylococci* and *Salmonellae* in ... 125

Meat
effect of freezing rate on appearance, palatability, and vitamin content of beef..... 8
effect of thawing and cooking methods on palatability and nutritive value of frozen ground meat
beef..... 249
lamb..... 256
pork..... 237
Metabolic characteristics of white potato in storage..... 192
Microbiological oxidation of ethanol in volatile fruit concentrates..... 347
Milk solids in food preparations..... 216
Moisture, effect on rancidity in fats..... 313
Mold growth in intact eggs, prevention of, with cationic detergents..... 1
Monosodium glutamate, effect on the taste of pure sucrose and sodium chloride..... 459

Niacin content
of dried beans as affected by variety and locality of growing..... 308
of tropical foods..... 465
Nicaragua, composition of food plants of..... 355
Non-fat dry milk solids in food preparation. Effect on viscosity and gel strength..... 200
Non-dry fat milk solids in food preparation..... 216
Nutritional value of
frozen ground meat, as influenced by thawing and cooking methods; *see* Beef, Lamb, Pork
peanut protein..... 498
sausage and other table-ready meats as affected by processing..... 302

Objective and subjective studies on factors affecting toughness and stringiness of kale..... 471
Observations on sloughing of potatoes..... 331
Oxidation of ethanol, microbiological, in volatile fruit concentrates..... 347

Palatability, effect of freezing rate on, in beef..... 8
Palatability and nutritive value of frozen ground meat, as effected by thawing and cooking methods; *see* Beef, Lamb, Pork
Peaches, canned, *Leuconostoc mesenteroides* as cause of ropiness in..... 415
Peanut butter
expansibility and specific volume of stabilized and unstabilized..... 297
heat capacity of stabilized..... 146
Peanut protein, nutritional value of..... 498
Pork, palatability and nutritive value as influenced by thawing and cooking methods.. 237
Potatoes
metabolic characteristics in storage..... 192
observations on sloughing of..... 331
Practical method for controlling atmospheres for use in food research..... 343
Properties on non-fat dry milk solids in food preparation
effects of viscosity and gel strength..... 200
using typical foods..... 216
Processing, effect on nutritive values of sausage and other table-ready meats..... 302
Protein, peanut, nutritional value of..... 498
Peroxidase, thermal destruction and stability of, in acid foods..... 114
Putrefactive anaerobes as spoilage agents in canned foods..... 62

Quality of cakes made with fat, effect of baking pan material on heat penetration during baking..... 155
Quality of freshly baked cakes, thawed frozen baked cakes and cakes prepared from frozen batters..... 169

Rancidity in fats, as affected by salt and moisture..... 313
Rat, effect of single and repeated doses of gossypol on..... 232
Reduced ascorbic acid content of foods served in institutional quantities..... 372
Relation of concentration of canned tomato products to storage losses of ascorbic acid..... 405

Relation of variety and locality to niacin, thiamine, and riboflavin content of dried beans ... 308
Riboflavin content of dried beans as affected by variety and locality of growing ... 308
Riboflavin, retention in vegetables preserved by freezing ... 53
Ropiness in canned peaches, as caused by *Leuconostoc mesenteroides* ... 415
Rutin content of asparagus ... 150

Salad and french dressing, spoilage in, due to yeasts ... 135
Salad dressing
  bacterial and chemical analyses of ... 138
  viability of food-poisoning *Staphylococci* and *Salmonellae* in ... 125
Salmonellae
  in boiled duck's eggs ... 340
  viability of food-poisoning, in salad dressing and mayonnaise ... 125
Salt, effect on rancidity in fats ... 313
Sausage, nutritive value of, as affected by processing ... 302
Sloughing of potatoes ... 331
Sodium chloride, effect of monosodium glutamate on taste of ... 459
Specific volume of stabilized and unstabilized peanut butter ... 297
Spices, bacterial flora of, effect of supervoltage cathode rays on ... 490
Spoilage agents in canned foods, studies of putrefactive anaerobes ... 62
Spoilage in salad and french dressing due to yeasts ... 135
Spores of *Clostridium botulinum* in Georgia soil ... 454
Stabilized and unstabilized peanut butter, expansibility and specific volume of ... 297
Staphylococci and *Salmonellae*, viability of food-poisoning, in salad dressing and mayonnaise ... 125
Storage life of butternut squashes as effected by darkness ... 99
Storage losses as ascorbic acid in canned tomato products, as influenced by concentration ... 405
Stringiness of kale, factors affecting ... 471
Subjective studies on factors affecting toughness and stringiness of kale ... 471
Sucrose, effect of monosodium glutamate on taste of ... 459
Supervoltage cathode rays, effect on bacterial flora of spices ... 490
Survival of *Salmonellae* in boiled duck's eggs ... 340
Squashes, effect of darkness on storage life ... 99

Table-ready meats, nutritive value of, as affected by processing ... 302
Thawing and Cooking Methods, effect on palatability and nutritive value of frozen ground meat; *see* Beef, Lamb, Pork
Thermal destruction and stability of peroxidase in acid foods ... 114
Thiamine, as influenced by cooking method in kale ... 223
Thiamine content of dried beans as affected by variety and locality of growing ... 308
Tomato juice, inhibitory action of citric acid on flat-sour organisms in ... 107
Tomato paste, factors influencing quality of California commercial tomato paste ... 366
Toughness of kale, factors affecting ... 471
Tropical foods, growth response of folic acid-depleted rats to ... 326
Tropical foods, niacin content of ... 484

Viability of food-poisoning *Staphylococci* and *Salmonellae* in salad dressing and mayonnaise ... 125
Viscosity, effect of non-fat dry milk solids in food preparation on ... 200
Vitamin content
  effect of freezing rate on, in beef ... 8
  of citrus products ... 179
Volatile components of chicken broth ... 322
Volatile fraction of apples, composition of ... 68
Volatile fruit concentrates, oxidation of ethanol in, by microbiological oxidation ... 347

West Indian cherry, ascorbic acid content and other characteristics ... 103

Yeasts, causing spoilage of salad and french dressing ... 135

Food Research

EDITORIAL BOARD

FRED W. TANNER
Z. I. KERTESZ

SAMUEL C. PRESCOTT — L. B. JENSEN
F. C. BLANCK — MAX LEVINE
E. J. CAMERON — A. G. LOCHHEAD
C. R. FELLERS — R. W. PILCHER
EVELYN G. HALLIDAY — D. K. TRESSLER
M. A. JOSLYN — A. L. WHITING

ROBERT J. GARRARD, *Managing Editor*

VOLUME 15

JANUARY-DECEMBER, 1950

THE GARRARD PRESS
CHAMPAIGN, ILLINOIS

Found Research

CONTENTS

NUMBER 1, JANUARY-FEBRUARY, 1950

Prevention of Mold Growth in Intact Eggs by Treatment With a Cationic Detergent. W. D. Yushok and Alexis L. Romanoff 1

Effect of Freezing Rate on Meat. Appearance, Palatability, and Vitamin Content of Beef. Frank A. Lee, Robert F. Brooks, A. M. Pearson, John I. Miller, and Frances Volz 8

Composition of Food Plants of Central America. II. Guatemala. Hazel E. Munsell, Louis O. Williams, Louise P. Guild, Cynthia B. Troescher, Gertrude Nightingale, and Robert S. Harris 16

Composition of Food Plants of Central America. III. Guatemala. Hazel E. Munsell, Louis O. Williams, Louise P. Guild, Cynthia B. Troescher, Gertrude Nightingale, and Robert S. Harris 34

Retention of Riboflavin in Vegetables Preserved by Freezing. Frances O. Van Duyne, Jean Chase Wolfe, and Royene F. Owen 53

Studies on Putrefactive Anaerobes as Spoilage Agents in Canned Foods. Valborg Aschehoug and Erling Jansen 62

Composition of a Volatile Fraction of Apples, Jonathan W. White, Jr. 68

Browning of Ascorbic Acid in Pure Solutions. Merton P. Lamden and Robert S. Harris 79

NUMBER 2, MARCH-APRIL, 1950

Bacterial Flora of Frozen Egg Products. Carolyn Wrinkle, H. H. Weiser, and A. R. Winter 91

Darkness Prolongs Storage Life of Butternut Squashes. Arthur D. Holmes 99

Ascorbic Acid Content and Other Characteristics of the West Indian Cherry. Conrado F. Asenjo and Carlos G. Moscoso 103

Inhibitory Action of Citric Acid on Tomato Juice Flat-Sour Organisms. D. I. Murdock 107

Thermal Destruction and Stability of Peroxidase in Acid Foods. Edward A. Nebesky, William B. Esselen, Jr., A. M. Kaplan, and Carl R. Fellers 114

Viability of Food-Poisoning *Staphylococci* and *Salmonellae* in Salad Dressing and Mayonnaise. Mary Catherine Wethington and F. W. Fabian 125

Spoilage in Salad and French Dressing Due to Yeasts. F. W. Fabian and Mary Catherine Wethington 135

Bacterial and Chemical Analyses of Mayonnaise, Salad Dressing, and Related Products. F. W. Fabian and Mary Catherine Wethington 138

Heat Capacity of Stabilized Peanut Butter. T. L. Ward, W. S. Singleton, and A. F. Freeman 146

Rutin Content of Asparagus. A. E. Stevenson 150

Effect of Baking Pan Material on Heat Penetration During Baking and on Quality of Cakes Made With Fat. Helen Charley 155

Comparison of the Quality of Freshly Baked Cakes, Thawed Frozen Baked Cakes, and Cakes Prepared From Batters Which Had Been Frozen. Royene F. Owen and Frances O. Van Duyne 169

NUMBER 3, MAY-JUNE, 1950

Vitamin Content of Citrus Products. W. A. Krehl and George R. Cowgill..... 179

Changes in Metabolic Characteristics of White Potato as Affected by Conditions of Storage. James S. Wallerstein, Robert Reinhart, Hilton Levy, and Arthur L. Schade..... 192

Use and Properties of Non-Fat Dry Milk Solids in Food Preparation. I. Effect on Viscosity and Gel Strength. Lura M. Morse, Dorothy S. Davis, and E. L. Jack.. 200

Use and Properties of Non-Fat Dry Milk Solids in Food Preparation. II. Use in Typical Foods. Lura M. Morse, Dorothy S. Davis, and E. L. Jack..... 216

Influence of Cooking Method on Ascorbic Acid and Thiamine Contents of Four Varieties of Kale *(Brassica oleracea v. acephala)*. Martha Potgieter and Mary L. Greenwood..... 223

Effect of Single and Repeated Doses of Gossypol on the Rat. Edward Eagle and Henry F. Bialek..... 232

Effect of Thawing and Cooking Methods on Palatability and Nutritive Value of Frozen Ground Meat. I. Pork. Kathryn Causey, Ella Gleim Andreassen, Mary Elizabeth Hausrath, Carmel Along, Paul E. Ramstad, and Faith Fenton..... 237

Effect of Thawing and Cooking Methods on Palatability and Nutritive Value of Frozen Ground Meat. II. Beef. Kathryn Causey, Mary Elizabeth Hausrath, Paul E. Ramstad, and Faith Fenton..... 249

Effect of Thawing and Cooking Methods on Palatability and Nutritive Value of Frozen Ground Meat. III. Lamb. Kathryn Causey, Mary Elizabeth Hausrath, Paul E. Ramstad, and Faith Fenton..... 256

NUMBER 4, JULY-AUGUST, 1950

Composition of Food Plants of Central American. IV. El Salvador. Hazel E. Munsell, Louis O. Williams, Louise P. Guild, Cynthia B. Troescher, Gertrude Nightingale, Lucille T. Kelley, and Robert S. Harris..... 263

Expansibility and Specific Volume of Stabilized and Unstabilized Peanut Butter. W. S. Singleton and A. F. Freeman..... 297

Nutritive Values of Sausage and Other Table-Ready Meats as Affected by Processing. J. F. Beuk, J. F. Fried, and E. E. Rice..... 302

Relation of Variety and Locality to Niacin, Thiamine, and Riboflavin Content of Dried Beans Grown in Three Years. Helen W. Gough and Edith M. Lantz..... 308

Some Effects of Salt and Moisture on Rancidity in Fats. Irene Chang and Betty M. Watts..... 313

Chicken Flavor: Separation and Concentration of Its Volatile Components From Broth. Robert J. Bouthilet..... 322

Growth Response of Folic Acid-Depleted Rats to Supplementation With Tropical Foods. Conrado F. Asenjo, Ana I. Muniz, and Maria Leonor Quintana..... 326

Observations on Sloughing of Potatoes. R. T. Whittenberger and G. C. Nutting..... 331

Survival of *Salmonellae* in Boiled Ducks' Eggs. A. Clarenburg and H. C. Burger.... 340

NUMBER 5, SEPTEMBER-OCTOBER, 1950

A Practical Method for Controlling Atmospheres for Use in Food Research. W. S. Ogilvy, M. V. Burke, and J. C. Ayres..... 343

Microbiological Oxidation of Ethanol in Volatile Fruit Concentrates. R. Kocholaty.. 347

Composition of Food Plants of Central America. V. Nicaragua. Hazel E. Munsell, Louis O. Williams, Louise P. Guild, Cynthia B. Troescher, and Robert S. Harris..... 355

Factors Influencing Quality of Tomato Paste. I. Chemical Composition of California Commercial Tomato Paste. J. C. Underwood..... 366

Reduced Ascorbic Acid Content of Foods Served in Institutional Quantities. Clara A. Storvick, Bessie L. Davey, Ruth M. Nitchals, and Ruth E. Coffey..... 373

Composition of Food Plants of Central America. VI. Costa Rica. Hazel E. Munsell, Louis O. Williams, Louise P. Guild, Lucille T. Kelley, Ann M. McNally, and Robert S. Harris..... 379

Relation of Concentration of Canned Tomato Products to Storage Losses of Ascorbic Acid. Miriam Hummel and Ruth Okey..... 405

Leuconostoc mesenteroides as the Cause of Ropiness in Canned Peaches. F. W. Fabian and R. H. Henderson..... 415

NUMBER 6, NOVEMBER-DECEMBER, 1950

Composition of Food Plants of Central America. VII. Honduras. Hazel E. Munsell, Louis O. Williams, Louise P. Guild, Lucille T. Kelley, and Robert S. Harris..... 421

Composition of Food Plants of Central America. VIII. Guatemala. Hazel E. Munsell, Louis O. Williams, Louise P. Guild, Lucille T. Kelley, Ann M. McNally, and Robert S. Harris..... 439

Spores of *Clostridium botulinum* in Georgia Soil. Roy E. Morse, John J. Powers, and Carl J. Williams..... 454

Effect of Monosodium Glutamate on Taste of Pure Sucrose and Sodium Chloride. Ernest E. Lockhart and Jean Murray Gainer..... 459

Niacin Content of Tropical Foods. Conrado F. Asenjo, Oro de Borinquen Segundo, Ana I. Muñiz, and Aida M. Canals..... 465

Objective and Subjective Studies on Factors Affecting Toughness and Stringiness of Kale *(Brassica oleracea acephala)*. Karla Longrée and Faith Fenton..... 471

Effect of Supervoltage Cathode Rays on Bacterial Flora of Spices and Other Dry Food Materials. Bernard E. Proctor, Samuel A. Goldblith, and Harvey Fram.... 490

The Carotenes of Cantaloupes. M. G. Vavich and A. R. Kemmerer..... 494

Nutritional Value of Peanut Protein. Edward A. Murphy and Max S. Dunn..... 498

NOTICE TO CONTRIBUTORS

No paper embodying data previously or simultaneously to be published should be submitted. Authors are requested to examine a recent issue of Food Research for details of style and format.

Manuscripts and drawings should be sent by prepaid express or registered mail to the editor-in-chief. Submission of a carbon copy with the original copy will greatly accelerate publication since the paper may be reviewed simultaneously by two readers. A carbon copy also should be retained by the author since the editors cannot assume responsibility for manuscripts. The original typewritten copy should be submitted. A carbon copy alone is not acceptable.

Manuscripts should be copied double space and preferably should be sent flat—not rolled or folded. Corrections which have been made should be clear and legible. As far as possible and reasonable, manuscripts should be numbered consecutively from beginning to end. Interpolated pages may be noted, 45a, 45b, etc., in accordance with the number of the preceding page. Should pages be removed from the manuscript for any reason the preceding page should be double numbered.

Foreign language phrases should be underlined in the manuscript for italics when printed, as in vacuo, in vitro. Complete generic and specific names of microorganisms should be cited and underlined. Generic names alone should also be underlined. Please do not abbreviate.

Original drawings or photographs of drawings should accompany manuscripts. If it is necessary to include photographs for half-tone reproductions, glossy prints should be submitted. Authors should indicate on the manuscript the position of text figures.

Manuscripts and drawings should be submitted in complete and finished form, accompanied by the author's complete address. All drawings should also be marked with the author's name. Food Research reserves the privilege of editing manuscripts to make them conform with the adopted style of the journal or of returning them to the author for revision. Changes which are made by the editors may be reviewed by authors when they examine proof. ☞ When the amount of tabular or illustrative material is judged to be excessive or unusually expensive, authors may be requested to pay the excess cost.

Tables, quotations (extracts of over five lines), and all subsidiary matter usually set in type smaller than the text, should be typewritten on separate sheets and placed with the text in correct sequence. Footnotes should be in with the text (reference numbers only), but typewritten continuously on separate sheets, and numbered consecutively. Explanations of figures should be treated in the same manner and, like footnotes, should be put at the end of the text copy. A condensed title for running page headline, not to exceed thirty-five letters and spaces, may be given. Citations of literature should be made in the text by reference to authors with date in parenthesis indicating the year of publication. Bibliographic references should be arranged alphabetically by authors at end of article, with a complete reference, i.e., authors, date, title, volume and bounding pages. If reference is a book, the publisher and date of edition cited should be noted. Abbreviations of titles of publications should, in general, be in accordance with those given in List of Periodicals Abstracted by Chemical Abstracts (1936), and Supplement thereto (1942).

Figures should be drawn for reproduction as line or half-tone engravings, unless the author is prepared to defray the additional cost of a more expensive form of illustration. In grouping the drawings it should be borne in mind that, after the reduction has been made, text figures are not to exceed the dimensions of the printed matter on the page, 4¾ x 6¾ inches. Single plates may be 3 x 7⅛ inches, or less. Double plates will not be accepted.

Figures, plates, and tables should be numbered consecutively, using Arabic numbers. The reduction desired should be clearly indicated on the margin of the drawing.

All drawings intended for photographic reproduction either as line engravings (black-ink pen lines and dots) or half-tone plates (wash and brush work) should be made on white or blue-white paper or bristol board, not on cream-white or yellow-toned. Photographs intended for half-tone reproduction should be securely mounted with colorless paste—never with glue, which discolors the photograph.

Galley proofs and engraver's proofs of figures are sent to the author. All corrections should be clearly marked thereon. If necessary, a corrected galley proof may be sent to authors.

The editors of Food Research recommend that prospective authors follow the recommendations for preparation of manuscripts in such guides as "The Wistar Institute Style Brief," published by the Wistar Institute of Philadelphia, Pennsylvania, or "A Manual of Style" of the University of Chicago Press.

DIFCO

for Microbiological Assay

of

VITAMINS and AMINO ACIDS

Bacto dehydrated media containing all the necessary nutriments and growth factors for the microbiological assay of vitamins and amino acids are now available from Difco. These basal media require only the addition of graduated amounts of the substance under assay to obtain linear growth of the test organism for construction of the standard curve. The vitamin or amino acid content of the material under assay is determined by adding appropriate concentrations of the test substance to the basal medium and comparing the growth response obtained with the standard.

BACTO-FOLIC ACID ASSAY MEDIUM
BACTO-NIACIN ASSAY MEDIUM
BACTO-PANTOTHENATE ASSAY MEDIUM
BACTO-PYRIDOXINE ASSAY MEDIUM
BACTO-RIBOFLAVIN ASSAY MEDIUM
BACTO-THIAMIN ASSAY MEDIUM
BACTO-TRYPTOPHANE ASSAY MEDIUM
BACTO-VITAMIN B_{12} ASSAY MEDIUM

* * * * *

The method employed in carrying stock cultures of the test organisms and preparing the inoculum for microbiological assay is important. The following media have been developed especially for carrying stock cultures and for preparation of the inoculum.

BACTO-MICRO ASSAY CULTURE AGAR
BACTO-MICRO INOCULUM BROTH
BACTO-NEUROSPORA CULTURE AGAR

* * * * *

BACTO-VITAMIN FREE CASAMINO ACIDS, dehydrated, is an acid hydrolysate of vitamin free casein prepared especially for laboratories investigating microbiological assay of vitamins.

Descriptive literature is available upon request.

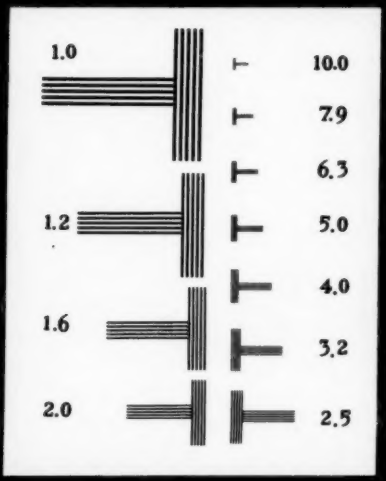
Specify "DIFCO"

The Trade Name of the Pioneers in the Research and Development of Bacto-Peptone and Dehydrated Culture Media

DIFCO LABORATORIES

DETROIT 1, MICHIGAN

RESOLUTION CHART



100 MILLIMETERS

INSTRUCTIONS Resolution is expressed in terms of the lines per millimeter recorded by a particular film under specified conditions. Numerals in chart indicate the number of lines per millimeter in adjacent "T-shaped" groupings.

In microfilming, it is necessary to determine the reduction ratio and multiply the number of lines in the chart by this value to find the number of lines recorded by the film. As an aid in determining the reduction ratio, the line above is 100 millimeters in length. Measuring this line in the film image and dividing the length into 100 gives the reduction ratio. Example: the line is 20 mm. long in the film image, and $100/20 = 5$.

Examine "T-shaped" line groupings in the film with microscope, and note the number adjacent to finest lines recorded sharply and distinctly. Multiply this number by the reduction factor to obtain resolving power in lines per millimeter. Example: 7.9 group of lines is clearly recorded while lines in the 10.0 group are not distinctly separated. Reduction ratio is 5, and $7.9 \times 5 = 39.5$ lines per millimeter recorded satisfactorily. $10.0 \times 5 = 50$ lines per millimeter which are not recorded satisfactorily. Under the particular conditions, maximum resolution is between 39.5 and 50 lines per millimeter.

Resolution, as measured on the film, is a test of the entire photographic system, including lens, exposure, processing, and other factors. These rarely utilize maximum resolution of the film. Vibrations during exposure, lack of critical focus, and exposures yielding very dense negatives are to be avoided.

THIS PUBLICATION IS REPRODUCED BY AGREEMENT WITH THE COPYRIGHT OWNER. EXTENSIVE DUPLICATION OR RESALE WITHOUT PERMISSION IS PROHIBITED.